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ABSTRACT

Based on research and the work of groups engaged in mathematics and science education reform, this document describes the teaching, assessment, and professional development necessary for practitioners in the Pacific region to bring about mathematical and scientific literacy by improving the interaction among students, teachers, and content. The introduction describes six characteristics of effective mathematics and science teachers, the importance of mathematics and science literacy, and shifts in education in these fields; it also includes a discussion of learning. The 12 teaching standards describe the knowledge, skills, and attitudes teachers should have to successfully help students achieve literacy. The nine assessment standards describe the essential characteristics of quality assessment of student learning and the principles which guide assessment decision making. Also covered are assessment and the vision for Pacific students, a story about standards in action, and discussions of purposes of assessment, types of assessment and the interaction of culture and assessment. The seven professional development standards that conclude the document describe a variety of means through which teachers can develop, maintain, and enhance their skills. Appendixes contain a glossary and a bibliography of sources of more information on the Pacific Standards. (Contains 18 references.) (JB)

PACIFIC STANDARDS FOR EXCELLENCE IN

TEACHING, ASSESSMENT AND PROFESSIONAL DEVELOPMENT

DEVELOPED BY THE

PACIFIC MATHEMATICS and SCIENCE LEADERSHIP TEAM

September 1995

PACIFIC MATHEMATICS AND SCIENCE REGIONAL CONSORTIUM

PACIFIC REGION EDUCATIONAL LABORATORY

PACIFIC REGION EDUCATIONAL LABORATORY
828 Fort Street Mall ◆ Suite 500
Honolulu, Hawaii 96813-4321
(808) 533-6000 ◆ FAX: (808) 533-7599
e-mail: askprel@prel.hawaii.edu

Institutional Services
828 Fort Street Mall ◆ Suite 500
Honolulu, Hawaii 96813-4321
(808) 533-6000 ◆ FAX: (808) 533-7599
e-mail: askprel@prel.hawaii.edu

Eastern Pacific Service Center
828 Fort Street Mall ◆ Suite 300
Honolulu, Hawaii 96813-4321
(808) 533-6000 ◆ FAX: (808) 533-7599
e-mail: askprel@prel.hawaii.edu

Western Pacific Service Center
Suite 203, Bank of Hawaii Building
Marina Heights Business Park
PPP 145 ◆ Box 10000
Puerto Rico, Saipan, MP 96950
Phone: (670) 323-6000/1/2
FAX: (670) 323-7735
e-mail: prelwest@prel.hawaii.edu

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PACST000003

VISION

ALL PACIFIC CHILDREN WILL BE SCIENTIFICALLY AND MATHEMATICALLY LITERATE:

KNOWLEDGEABLE,

CAPABLE,

AND

CARING.

VISION IN ACTION

When the vision is put into action .....

students will be ...

- literate in mathematics and science,
- effective problem solvers in a changing world,
- capable, competent, and caring.

teachers will be ...

- more confident in their knowledge,
- models of our cultures,
- positive motivators in the classroom,
- supporters and caring linkers of students, families, and communities.

teaching will become ...

- more student centered,
- more inquiry and task based,
- a process of guiding students to build on their prior knowledge to develop understanding and capabilities.

classrooms will be ...

- true centers of learning,
- adequately equipped,
- inclusive of home and community.

CONTENTS

Pacific Standards for Professional Development

Tables

Figure

Appendices

PREFACE

In 1992, the Pacific Mathematics and Science Regional Consortium was formed with funding from the U.S. Department of Education's Dwight D. Eisenhower National Program for Mathematics and Science Education. Headquartered in Honolulu, Hawai'i, at the Pacific Region Educational Laboratory (PREL), the consortium is a collaboration of PREL, the University of Hawai'i's Curriculum Research & Development Group (CRDG), the Moanalua Gardens Foundation, and the Departments of Education of the region's 10 entities: American Samoa; Commonwealth of the Northern Mariana Islands; Federated States of Micronesia (Chuuk, Kosrae, Pohnpei, and Yap); Guam; Hawai'i; Republic of the Marshall Islands; and Republic of Palau.

One of the first tasks the consortium undertook was the development of standards in mathematics and science appropriate to the Pacific region. The resulting documents, products of the Pacific Mathematics and Science Leadership Team, contain challenging standards for mathematics and science education in the Pacific region.

The Pacific Standards for Excellence Series

The *Pacific Standards for Excellence Series* currently consists of this document and two others: the *Pacific Standards for Excellence in Mathematics* and the *Pacific Standards for Excellence in Science*. These documents are the result of widespread collaboration and set ambitious goals for mathematics and science education in the region. They are targets for students, teachers, and schools to strive for.

The *Pacific Standards for Excellence in Mathematics* and *Pacific Standards for Excellence in Science* identify what all students should know, be able to do, and care about as a result of their education. The *Pacific Standards for Excellence in Teaching, Assessment and Professional Development* describes the teaching, assessment, and professional development necessary to create learning environments which are supportive of students who are striving to achieve mathematical and scientific literacy.

All three documents are based upon research and the similar work of outstanding groups engaged in mathematics and science education reform. The standards contained in the *Pacific Standards for Excellence Series* are challenging, while acknowledging the Pacific region as a variety of environments, cultures, and experiences. The three are working documents which will continue to be refined and grow as they are implemented.

The Pacific Standards for Excellence in Teaching, Assessment and Professional Development

The *Pacific Standards for Excellence in Teaching, Assessment and Professional Development* describe some of the key ingredients necessary to bring about mathematical and scientific literacy by improving the interaction among students, teachers, and content. The teaching standards describe the knowledge, skills, and attitudes teachers should have to successfully help students achieve literacy. The assessment standards describe the essential characteristics of quality assessment of student learning and the principles which guide assessment decision-making. The professional development standards describe a variety of means through which teachers can develop, maintain, and enhance their skills.

This document is primarily for teachers, administrators, curriculum planners, and those responsible for pre and inservice professional development. As school staffs, districts, and other groups propose solutions to problems and questions related to mathematics and science education, these standards should be used as criteria against which to judge their ideas. Standards should also be used to plan for staff development, facilities improvement, and technology implementation. Additionally, the standards are useful for community leaders, legislators, parents, and others concerned with education. Finally, it is hoped the document will be useful to others outside the Pacific region who are interested in and concerned about education and the development of mathematically and scientifically literate citizens.

ACKNOWLEDGMENTS

The *Pacific Standards for Excellence in Teaching, Assessment and Professional Development* builds upon the work of a number of outstanding groups, including the National Research Council, the National Council of Teachers of Mathematics, the National Staff Development Council, and the National Board of Professional Teaching Standards. This document reflects many of the ideas put forth by these groups.

This document is the result of work by individuals representing each of the entities in the region, the Curriculum Research and Development Group (CRDG) at the University of Hawai`i, and the Pacific Mathematics and Science Regional Consortium at PREL.

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Philo Jennings, Department of Education, American Samoa
Netini Sene, Department of Education, American Samoa
Sofa'i Tuato`o, Department of Education, American Samoa (Pacific Educator in Residence at PREL)
Jackie Quitugua, Public School System, Commonwealth of the Northern Mariana Islands
Nicholas Sablan, Public School System, Commonwealth of the Northern Mariana Islands
Aurelio Sauder, Department of Education, Chuuk, Federated States of Micronesia
Sanfio Sony, Department of Education, Chuuk, Federated States of Micronesia
Gibson Mongkeya, Department of Education, Kosrae, Federated States of Micronesia
Robert Taulung, Department of Education, Kosrae, Federated States of Micronesia
Pernis Diopulos, Department of Education, Pohnpei, Federated States of Micronesia
Selihter Joseph, Department of Education, Pohnpei, Federated States of Micronesia
Martin Weirlangt, Department of Education, Pohnpei, Federated States of Micronesia
Weldis Welley, FSM National Department of Education, Federated States of Micronesia
Ginny Fenenigog, Department of Education, Yap, Federated States of Micronesia
Stan Yiluy, Department of Education, Yap, Federated States of Micronesia
Teresita Mesa, Public School System, Guam
John Simpson, Public School System, Guam
Jeanne Nelson, Kamehameha Schools Bernice Pauahi Bishop Estate, Hawai`i
Brian Morioka, Department of Education, Hawai`i
Charlotte Okada, Department of Education, Hawai`i
Bedinin Joseph, Ministry of Education, Republic of the Marshall Islands
Juanita Rilometo, Ministry of Education, Republic of the Marshall Islands
Elizabeth Weimer, Ministry of Education, Republic of the Marshall Islands
Tangy Anastacio, Ministry of Education, Republic of Palau
Bernie Keldermans, Ministry of Education, Republic of Palau

April Olkeriil, Ministry of Education, Republic of Palau
Nancy Ngirirakel, Ministry of Education, Republic of Palau
Alice Borja, Pacific Mathematics and Science Regional Consortium, PREL
Kathy Busick, Pacific Mathematics and Science Regional Consortium, PREL
Winona Chang, Pacific Mathematics and Science Regional Consortium, PREL
Paul Dumas, Pacific Mathematics and Science Regional Consortium, PREL
Pam Legdesog, Pacific Mathematics and Science Regional Consortium, PREL
Hannah Slovin, Curriculum Research and Development Group, University of Hawai`i
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Armstrong, Thomas. *Multiple Intelligences in the Classroom*. Alexandria, VA: Association for Supervision and Curriculum Development. 1994.

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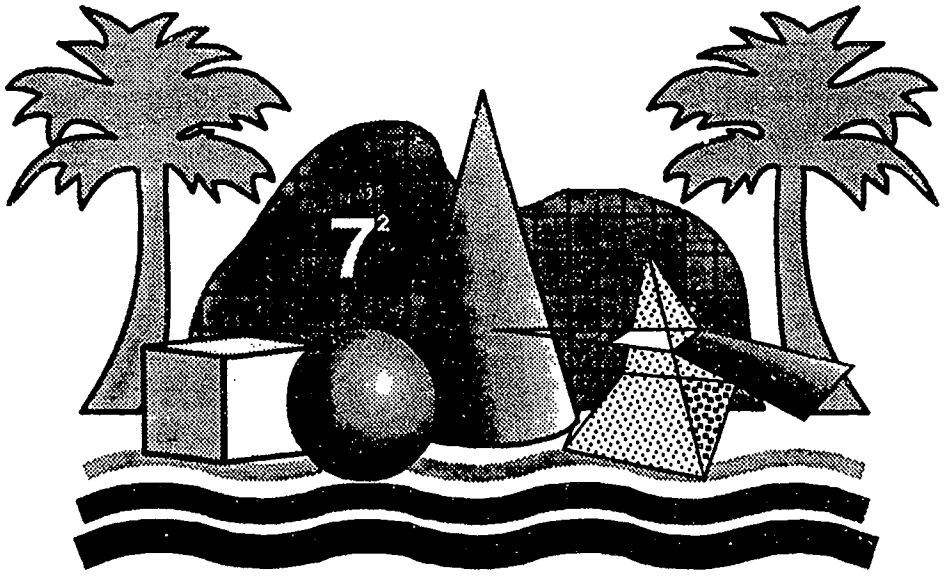
About Teaching, Assessment, and Professional Development



INTRODUCTION

This document, the *Pacific Standards for Excellence in Teaching, Assessment and Professional Development*, describes regional goals for teaching, assessment and professional development. The mathematics and science standards will be worthwhile only if they are implemented and lead to improved interaction between teachers and students and enhanced student learning. Achieving the standards described in this document will enable the successful implementation of the "content" standards and provide students with opportunities to achieve literacy.

The development of the teaching, assessment, and professional development standards was based upon six characteristics that highly effective mathematics and science teachers have in common:

1. **Effective teachers are committed to students and their learning.**
   They believe that all students can learn, and they treat all students equitably while recognizing individual differences. They make an effort to be aware of the students' interests, abilities, skills, knowledge, culture, and experiences in and outside of school. They develop students' intellectual capacity and their respect for learning. They foster students' self-esteem, character, and civic responsibility while respecting cultural, religious, and ethnic differences.

2. **Effective teachers know the subjects they teach and how to teach those subjects to students.**
   They have a rich knowledge of mathematics and science and appreciate how knowledge is gained, organized, linked to other disciplines, and applied in settings familiar to their students. They develop the critical and analytical capacities of their students. They have a deep understanding of how to teach. They incorporate the prevailing theories of learning and intelligence in their practice. They are aware of the ideas that students bring to the classroom and of strategies and instructional materials that can be effective in teaching. They understand where difficulties are likely to arise and are prepared to modify instruction accordingly. Their understanding of teaching allows them to create multiple paths for students to achieve an understanding of mathematics and science.

3. **Effective teachers are accomplished at creating learning environments that engage students and others in the learning process.**
   They create, maintain, and enrich instructional settings to capture and sustain their students' interest. They understand the appropriate use of a range of instructional strategies and can implement them as needed. They make effective use of instructional time. They engage individuals and groups of students to ensure a safe, nurturing learning environment. They understand how to motivate students to learn and how to maintain their interest even in

the face of temporary failure. They are eager to involve students, community members, and colleagues to complement their instruction.

4. **Effective teachers use a variety of methods to assess both individual and group progress.**
   They use multiple methods for measuring student growth and understanding and enable their students to demonstrate their learning in a variety of ways. They use assessment as a communication system and self-assessment is encouraged. They can clearly explain student performance to parents. They enrich and adjust their instruction to meet individual and group needs.

5. **Effective teachers reflect on their teaching and learn from experience.**
   They are models of educated persons. They have the ability to reason and see multiple perspectives, to be creative and take risks, and demonstrate an experimental and problem-solving orientation. They use their knowledge of human development, subject matter, and instruction and their knowledge of their students to make decisions about their teaching. They adjust their teaching based on observation and knowledge of their students. They examine their teaching, seek to expand their skills, deepen their knowledge, and adapt their teaching to new findings, ideas, and theories.

6. **Effective teachers are active members of learning communities.**
   They contribute to the effectiveness of the school by working collaboratively with others on instructional policy, curriculum development, and staff development. They are knowledgeable about specialized school and community resources that can enhance the learning experiences of their students and are skilled at employing such resources. They find ways to work with parents, engaging them productively in the work of education.

The teaching and assessment standards in this document provide further guidance to teachers seeking to achieve this level of effectiveness. The professional development standards provide criteria for designing and evaluating pre and inservice programs for mathematics and science educators in the region.

THE IMPORTANCE OF MATHEMATICAL AND SCIENTIFIC LITERACY

Mathematics, science, and technology are powerful forces that shape human life on earth. They have made societies productive, and they continue to have enormous potential to make lives better and richer and to keep the world safe and livable.

The study of mathematics and science is important because it enriches peoples' lives. It opens the human minds to a new appreciation of the beauty and precision that are around us. An understanding of mathematics and science enables people to take greater control of their lives and to face problems with courage and understanding. This understanding liberates people to imagine new questions and to set about finding new answers.

In the face of rapid development across the Pacific region and throughout the world, all citizens need to be mathematically and scientifically literate to function effectively and to help create and sustain a decent, just, and vigorous society. A literate person is one who understands the key concepts and principles of mathematics and science and uses this knowledge and ways of thinking in everyday life. Citizens today face a range of hard choices, from the personal (such as, how to avoid AIDS) to the global (such as, what to do about the greenhouse effect). People who understand both mathematics and science are better prepared to sort fact from fiction, make sensible decisions, and urge their leaders toward informed public policy choices.

Mathematical and scientific literacy is also economically important. The Pacific region will need people who are well grounded in mathematics and science in a range of specialized career fields. At the same time, there will be an increasing demand for workers, with a basic grasp of mathematics and science and the ability to solve problems and think creatively in all sectors of the region's economy. Quality mathematics and science education can equip students to become world-class adults in a scientific and technological society.

SHIFTS IN MATHEMATICS AND SCIENCE EDUCATION

Mathematics and science are more than bodies of knowledge. They represent a way of looking at the world and ordering one's experiences in it. The study of mathematics and science presents occasions to open young minds to new ideas and to equip students with the intellectual tools that will guide them as learners for the rest of their lives. Too often this is a missed opportunity.

Most schools today use a conventional approach to teaching these subjects. This approach presents science as a fixed body of facts, principles, and definitions, ordered sequentially, and divided into disciplines such as biology, chemistry, and physics. Mathematics instruction is usually lecture and practice. Students depend upon the teacher to supply the "correct" solution to problems and there is very little opportunity for creativity and critical thinking. In both mathematics and science classrooms, learning is dispensed by the teacher and the textbook, with students expected to master a range of topics by listening, reading, and repetitive practice. Instead of acquiring understanding, students learn isolated bits of information.

The approach to teaching described above does not work for most students. Somewhere in the middle grades students tend to lose interest, and by high school, many find mathematics and science difficult, boring, and irrelevant. Few take advanced courses. The result is that most adult citizens are not mathematically and scientifically literate. For example, it is not uncommon to find adults who do not know that the earth revolves around the sun once a year, or others who have difficulty estimating the cost of an item on sale at a 25 percent discount. According to many, this is the result of playing too much emphasis on covering too many topics superficially rather than in-depth learning; seatwork rather than activities; memorization rather than critical thinking; and recitation rather than well-reasoned argument.

The opportunity to learn is an important factor in the effort to achieve the goal of mathematical and scientific literacy for all Pacific children. Mathematics and science need to receive more attention. Teachers need to be comfortable with these subjects and must receive the preparation and inservice training they need to become effective mathematics and science teachers.

There are major efforts underway to move from conventional approaches to teaching and learning with new visions that reflect what is known about effective education. These efforts describe what all students should know and understand about mathematics and science, and they recommend teaching in ways designed to address all students' learning styles, abilities, and cultural backgrounds.

Review of these reform efforts reveals striking similarities that point the way to major shifts in content, instruction, assessment, and the professional development of educators implementing these new visions in schools and communities. These changes are summarized in Table 1 and are reflected throughout the *Pacific Standards for Excellence Series*.

Table 1: Shifts in Mathematics and Science Education

MOVING AWAY FROM	TOWARD
• Mathematics and science for some	• Mathematics and science for all
• Reading/language first	• Inquiry and activity-based instruction accessible to all
• Teacher as "imparter" of knowledge	• Teacher as facilitator of learning
• Content driven	• Constructivist approach that builds on prior knowledge
• Students as passive learners	• Students actively involved in building understanding
• Individual	• Collaborative/social
• Divorced from real world	• Mathematics and science applied to students' lives
• Atomistic/disconnected study	• Holistic/connected; integrated and thematic
• Single exposure to concepts	• Spiral curriculum; sequential
• Memorization/emphasis on arithmetic	• New definition of basic skills including modes of inquiry, thinking skills, and communication
• Paper/pencil testing almost exclusively	• Multidimensional assessment

THE NATURE OF LEARNING

There have been major changes and advances in education in the last decade that impact on the recommendations for change in Pacific mathematics and science programs. Previous teaching methods relied heavily on lecture, reading, and repetitive drill, with little opportunity for active, experiential learning. Recent developments in cognitive psychology, understanding of learning styles, and identification of multiple forms of intelligence emphasize learning that is hands-on, inquiry-oriented, and cooperative. It is now known that learners need a large amount of experience and information to understand new concepts and to apply them in new situations. Thus, if true learning is to occur, concepts must be pursued in depth. Lectures are often not the most effective way to teach and too often result in the ability to say the right words without any real understanding of what they mean or how to use and apply that knowledge.

Building on the emphasis on experiential, hands-on, inquiry learning characterized by the educational philosophies of John Dewey and Jean Piaget, a new conception of learning has emerged that researchers call ***constructivism***. In this view, learners build their own understandings that are complex, highly organized, and strongly tied to specific subject matter. Learning occurs when a student constructs his/her own knowledge by making connections between new information and their own existing knowledge.

Learning occurs when the child becomes aware of inconsistencies in his/her prior conception of the world and is helped either to abandon or restructure these concepts. Discussion among learners is essential for them to check their understanding against that of others and to construct new concepts. Teaching, then, is not simply giving information, but requires patient dialogue with and among students and multiple opportunities to experience phenomena.

The constructivist view is linked to four related ideas: student learning styles, multiple intelligences, cooperative learning, and integration.

Learning Styles

Educators have known for a long time that students learn in different ways, and yet in school they teach as if this were not so. In more recent years, the differences in the ways people learn have been researched and described by medical doctors, psychologists, educators and those involved in managing organizations. All point to similar conclusions about the ways people perceive and process new knowledge—learning styles.

There is a variety of ways of learning the same information and each individual has a mode of learning with which he/she is most comfortable, his/her preferred learning style. For example, Dr. Bernice McCarthy (1987) described four basic learning styles and the particular teaching strategies that are most effective for them to learn. These styles are summarized in Table 2.

Table 2: Four Basic Learning Styles (Adapted from The 4MAT System by Bernice McCarthy)

Learning Style	Characteristics	Strengths	Teaching Strategies
Innovative Learners	**SEEK:** meaning, personal involvement **INTERESTED IN:** people and culture **LEARN BY:** listening, talking to one another, sharing ideas	**STRENGTHS:** innovation and imagination **GOALS:** involvement with important issues **FAVORITE QUESTIONS:** "Why?", "Shouldn't we discuss it?" **CAREERS:** counseling, teaching	**EFFECTIVE STRATEGIES:** cooperative groups, simulations, involvement in actual classroom experiences, such as skits, brain-storming, and role playing
Analytic Learners	**SEEK:** facts and "expert" opinion **INTERESTED IN:** ideas more than people **LEARN BY:** collecting and analyzing information, re-examining facts	**STRENGTHS:** creating concepts and models **GOALS:** self-satisfaction, intellectual recognition (grades are important) **FAVORITE QUESTION:** "What?" **CAREERS:** science or math fields, research	**EFFECTIVE STRATEGIES:** conventional classrooms where teachers give information based on facts in textbooks
Common Sense Learners	**SEEK:** usability **INTERESTED IN:** knowing how things work, problem solving **LEARN BY:** testing ideas, hands-on activities, resent being given answers	**STRENGTHS:** the practical application of ideas **GOALS:** seek order and systematic structures **FAVORITE QUESTION:** "How does this work?" **CAREERS:** engineering, mechanics, nursing	**EFFECTIVE STRATEGIES:** building things, making models, doing experiments, inventing applications, field trips, and testing ideas
Dynamic Learners	**SEEK:** hidden possibilities **INTERESTED IN:** knowing what can be done with things, variety **LEARN BY:** taking action, trial-and-error, self-discovery	**STRENGTHS:** taking risks, working with people, reach accurate conclusions but have difficulty explaining them **GOAL:** to make things happen **FAVORITE QUESTION:** "What if?" **CAREERS:** sales, action-oriented jobs	**EFFECTIVE STRATEGIES:** opportunities to choose their own course of action, experimenting with things and experiences to discover new ideas, sharing what they learn with others

Because classrooms contain a mixture of students, all of these learning styles are present in every classroom. For teachers, the implications of this research point to the need to use a variety of instructional strategies in the classroom. Using only one teaching strategy, no matter how skilled the teacher, results in systematically excluding as much as 70 percent of the class. If all Pacific children are to become scientifically and mathematically literate, classrooms must provide diverse experiences that address the needs of a multitude of learning styles.

Multiple Intelligences

A major influence on views of learning has been the theory of multiple intelligences developed by Howard Gardner, a cognitive psychologist at Harvard University. Gardner challenges the view that intelligence is a single ability. He defines intelligence as the ability to solve problems or fashion products valued in at least one cultural setting. The human mind, he says, is a set of intelligences keyed to doing different kinds of tasks. He refers to these as:

- **Linguistic Intelligence:** The capacity to use words effectively, whether orally (e.g., as a storyteller) or in writing (e.g., as a poet or journalist). This intelligence includes the ability to use language to convince others, to remember information and to explain ideas and understandings.

- **Logical-Mathematical Intelligence:** The capacity to use numbers effectively (e.g., as a mathematician or accountant) and to reason well (e.g., as a scientist or computer programmer). Logical-mathematical intelligence is called upon for activities involving categorization, classification, inference, generalization, calculation, and hypothesis testing.

- **Spatial Intelligence:** The ability to perceive the visual-spatial world accurately (e.g., having a strong sense of location and direction) and to perform transformations upon those perceptions (e.g., as an interior decorator, architect, or artist). It includes the capacity to visualize and to graphically represent visual or spatial ideas.

- **Bodily-Kinesthetic Intelligence:** The ability to use one's whole body to express ideas and feelings (e.g., as an actor, an athlete, or a dancer) and the facility to use one's hands to produce or transform things (e.g., as a craftsperson, mechanic, or surgeon). This intelligence includes skills, such as coordination, balance, dexterity, strength, flexibility, and speed.

- **Musical Intelligence:** The capacity to perceive, discriminate, transform (e.g., as a composer), and express (e.g., as a performer) musical forms. This intelligence includes sensitivity to the rhythm, melody, and timbre of a musical piece. One can have an intuitive understanding of music, a formal understanding, or both.

- **Interpersonal Intelligence:** The ability to perceive the moods, intentions, motivations, and feelings of other people. This can include sensitivity to many different kinds of interpersonal cues; and the ability to respond to those cues in some useful way (e.g., to influence a group of people).

- **Intrapersonal Intelligence:** Self-knowledge and the ability to act on the basis of that knowledge. This intelligence includes having an accurate picture of one's strengths and limitations and the capacity for self-discipline, self-understanding, and self-esteem.

Gardner argues that traditional schooling develops only two of the seven kinds—linguistic and logical-mathematical—at the expense of the other five. Gardner insists that schools must center on persons, offering students choices, even within the same courses, and attending to each one personally so that all can enlarge their intelligences to the fullest. Examples of teaching materials and strategies that parallel Gardner's seven intelligences are described in Table 3.

Cooperative Learning

Social interaction is a critical part of learning. Working collaboratively in small groups is an instructional approach that provides children the opportunity to verbalize what they know and check it against what others know.

Simply put, cooperative grouping effectively promotes student learning. In the research studies comparing cooperative learning with competitive and/or individualistic learning, there has been no case in which cooperative learning was less effective and, in most cases, it was more effective in promoting student learning. Effective mathematics and science instruction incorporates a variety of teaching strategies. Competitive activities are good for practice, recall, and review. Individual activities are appropriate when a student must learn a specific skill or concept, and the attainment of that goal is important to the student. Cooperative learning is most appropriate for activities calling for problem solving, divergent thinking, and inquiry.

Integration

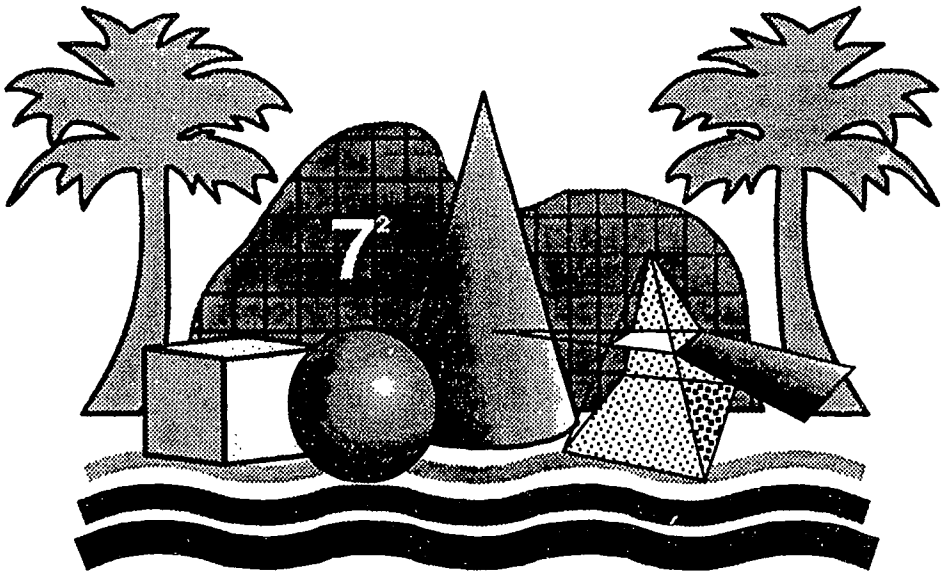
An extension of the emphasis of constructivism on connecting new learning to prior knowledge is an increasing recognition that mathematics and science neither exist nor should be taught in isolation. Leading the current reform movement, the Association for the Advancement of Science (AAAS), the National Science Teachers Association (NSTA), and the National Council of Teachers of Mathematics (NCTM) have strongly recommended that teaching be integrated within each content area and connected to other subject areas. This is not only a realization of how to better teach mathematics and science in elementary and secondary schools, but a reflection of how mathematics and science themselves have changed in the last decade, becoming increasingly interdisciplinary.

Table 3: Multiple Intelligences

Learners who are predominately	Think	Enjoy	Learn by
Linguistic	in words	reading, writing, telling stories, books, tapes, dialogue, discussion and debate	reading, writing, listening and talking about it
Logical-Mathematical	by reasoning	experimenting, questioning, puzzles, calculating, manipulatives	quantifying, thinking critically, and conceptualizing about it
Spatial	in images and pictures	designing, drawing, doodling, LEGOs, movies, slides, illustrated books	seeing, drawing, visualizing, and mapping it
Body-Kinesthetic	through physical sensations	dancing, running, building, touching, role playing, drama, hands-on learning	building it, acting it out, touching it, dancing it
Musical	via rhythms and melodies	singing, listening, concerts	singing it, rapping it, listening to it
Interpersonal	by bouncing ideas off other people	leading, organizing, friends, social gatherings, community events, clubs	collaborating with others on projects about it, teaching it to others
Intrapersonal	deep inside themselves	setting goals, meditating, planning, time alone, independent projects	connecting it to their personal lives, making choices and decisions with regard to it

Adapted from Multiple Intelligences in the Classroom by Thomas Armstrong

PACIFIC STANDARDS FOR TEACHING



TEACHING

Pacific Standards for Teaching

1. Broad and current knowledge of content
2. Knowledge of pedagogy
3. Addressing the diversity of learners
4. Orchestrating a variety of learning tasks
5. Curriculum planning and development
6. A community of learners
7. Mathematics and science for all students
8. Promoting discourse
9. Variety of assessment
10. Reflective learners
11. Involving families and communities
12. Professional growth

Introduction

Effective mathematics and science teachers have a coherent and integrated knowledge and vision of learning that is consistent with the *Pacific Standards for Excellence in Mathematics* and *in Science*. The teaching standards advocate a shift away from routine work that generally consists of lecture and rote learning to mathematics and science grounded in problem solving and higher-order thinking. This shift calls for new teaching methods that are student-centered, requiring teachers to rethink their concepts about how students learn and what instructional methods promote learning. Teachers must act as facilitators of learning in student-centered classrooms. Like the director of a play, teachers set the stage, but the students are the active participants in the learning process.

Most schools today use a conventional approach to teaching mathematics and science. Learning is dispensed by the teacher and the textbook, with students expected to master a range of topics by listening, reading, and writing. Instead of acquiring understanding, students learn bits of information without much meaning attached to them. This approach to teaching is not effective for lifelong learning. Students need to be prepared for the decisions they will have to make as adults—decisions about their lives, their careers, and their environment. Such decisions are becoming increasingly dependent on a clear understanding of mathematics, science, technology, and related fields. For students to begin to make these decisions, they need to engage in doing meaningful mathematics and science as described in these teaching standards.

Meaningful mathematics and science teaching encourages students to be curious, creative, open-minded, skeptical, willing to suspend initial judgments, able to collaborate with others, and be persistent in the face of challenges. In effective mathematics and science classrooms, the process of finding solutions to problems becomes equally or even more important than getting the right answers. Students are encouraged to ask questions, justify their reasoning, and reflect on their thinking and that of others. Strategies for developing these qualities and thinking processes are discussed in the teaching standards.

Achieving the goal of mathematical and scientific literacy means all Pacific children must be given the opportunity to learn. These teaching standards were developed to help support and guide Pacific teachers as they strive to grow professionally. They present new visions that will enable us to accomplish a comprehensive redesign of mathematics and science education, in which our children begin to learn significant mathematics and science in the earliest grades and continue to build knowledge through twelfth grade and beyond.

Teachers are knowledgeable, capable, and caring and are able to plan and implement quality instructional programs. It is hoped that teachers will take these standards and bring them to life in their classrooms. It is through this life that Pacific children can reach their vision.

Standard 1:
BROAD AND CURRENT KNOWLEDGE OF CONTENT

Effective mathematics and science teachers have a broad and current knowledge of the content appropriate to the level they are teaching.

The ability to steer a purposeful and effective learning course through the distractions of the school day and year presumes that teachers have a solid knowledge of the content of mathematics and science. It is the knowledge of these subjects that enables them to make mathematical and scientific ways of knowing available to students. Although it is not reasonable to expect teachers to have an in-depth knowledge of all of mathematics or science, it is important that they have a firm foundation that meets or exceeds the expectations for mathematical and scientific literacy as described in the *Pacific Standards for Excellence Series.*

Effective teachers also have the desire and capacity to continue building their understanding of mathematics and science throughout the course of their professional careers. A firm foundation includes, but is not limited to:

- an understanding of the fundamental concepts of mathematics and science,
- the ability to make conceptual connections between the ideas of mathematics, science and technology, and between these and other disciplines,
- the ability to use inquiry, reasoning, and problem-solving skills to pose and invite questions, design strategies, and carry out activities that improve instruction,
- an understanding of and appreciation for the role of mathematics and science in the development of societies and cultures and the ever increasing role that mathematics, science, and technology play in the everyday lives of people.

As professionals, mathematics and science teachers have a confident knowledge of the curriculum they teach. At the same time, they are co-learners with their students, who do not feel threatened when the limits of their own knowledge on a topic have been reached. The teachers are willing to respond to students' questions with, "I don't know, but here is how we can find out." These attributes are critical if mathematics and science teachers are to be lifelong learners, participate as leaders in their communities, and create environments where young people can develop into citizens able to reach personal goals and contribute to the general welfare of their societies.

Standard 2:
KNOWLEDGE OF PEDAGOGY

Effective mathematics and science teachers are knowledgeable of the current pedagogy for teaching and learning mathematics and science. They use a variety of teaching strategies that enable students to construct meaning.

Pedagogy is the art and science of teaching and involves many activities that are associated with being a teacher. In addition to focusing on specific teaching methods, pedagogy includes the planning and goal setting teachers do, the way they organize the classroom, and the ongoing decisions they make as a result of what happens in the classroom.

Current pedagogy in education is based on a student-centered curriculum. Such curriculum takes into account the previous knowledge students bring to the lessons and ways by which they use new learning experiences to build and refine their understanding of the concepts and develop the skills associated with those concepts. Through their involvement with the activities and tasks, students construct their own meaning and understanding of concepts. This is a change from a traditional view of teaching where the teacher tells the students what to do and how to do it.

To be effective, teachers must remain current on effective teaching strategies, keeping in mind the developmental levels of students. Teachers, as facilitators, design, implement, and make decisions about the curriculum and teaching strategies to promote development and growth of all students' learning over time. Effective mathematics and science teachers facilitate learning so that students can:

- integrate new information and ideas into existing knowledge,
- share ideas to validate or refute current understandings or beliefs,
- pursue their own inquiries,
- use a variety of materials and resources,
- solve problems,
- collaborate with each other,
- form connections within and outside the disciplines of mathematics and science.

Students construct meaning by engaging in inquiry. Student inquiry takes a variety of forms and occurs at different levels of depth and complexity. It ranges from concrete activities (such as taking a survey) which provide a basis for reflection and analysis to inquiry within the realm of abstractions

and theories; from direct hands-on activities to the use of literature and other media and technology. In classrooms in which student inquiry provides the basis for learning, students:

- participate fully in and quite often initiate activities related to their own learning,
- collaborate with their teachers and other students in the pursuit of ideas,
- formulate questions that can be answered through planned investigation,
- devise ways of answering questions, collect data, decide how to represent it, decide how to explain and justify their work to one another, learn to cope with shortcomings of equipment, and consider the challenges of others,
- assess the effectiveness of their efforts and make generalizations of their findings.

Highly effective teachers know that, as important as it is for students to acquire understanding of content, they must also learn the strategies and procedures for approaching problems mathematically and scientifically. A basic goal is to help students build the mental operations, habits of mind, and attitudes that characterize inquiry including:

- recognizing problems,
- asking questions about natural phenomena,
- formulating working hypotheses,
- observing phenomena,
- recording data accurately,
- reaching tentative conclusions consistent with data,
- expressing themselves clearly about the significance of findings,
- reflecting on the quality and completeness of their findings and conclusions.

Teachers know that students learn best by actively engaging in the tasks and events that make up the curriculum. Accordingly, teachers:

- organize their classrooms around frequent, hands-on explorations of natural phenomena,
- engage students as active investigators,
- arrange for a variety of activities and multiple opportunities to learn,
- help students construct their own understandings by interacting with other students and the teacher, applying ideas to the everyday world, and thinking and writing about their developing ideas,

- select age-appropriate activities that are likely to raise interesting, worthwhile questions, are relevant to students' lives, and flexible in allowing active participation of learners,
- help develop habits of mind such as curiosity, openness to new ideas, skepticism, demand for evidence, respect for reason, honesty and objectivity, acceptance of ambiguity, persistence, willingness to modify explanations in light of new evidence, and teamwork,
- use a variety of teaching strategies to acquaint their students with the major ideas of mathematics and science. Through experiments, field investigations, physical models, simulations, reading, videotapes, discussion, role playing, and other activities, they involve their students actively in making sense of new ideas.

Standard 3:
ADDRESSING THE DIVERSITY OF LEARNERS

Effective mathematics and science teachers understand the variety of ways students learn and appreciate the range of cultures, experiences, understandings, and interests that diverse students bring into the classroom.

Highly accomplished teachers recognize that every classroom is made up of unique individuals. Each of these students brings his/her own interests, understandings, experiences, and needs to the learning situation. In addition to the content, effective teachers consider their students and the variety of ways they learn when selecting, adapting, and delivering instruction that will encourage the active involvement of all learners. The teachers see mathematics and science as ways of satisfying students' natural curiosity about the world and their innate desire to make sense of their experiences.

In order to make informed decisions when designing instruction to meet the varied needs of their students, effective teachers build upon an understanding of:

- multiple intelligences and differences in learning styles among their students,
- ways to link tasks and activities to the students' surroundings and past experiences in order to further the students' efforts to construct meaning,
- the effectiveness of teaching strategies such as cooperative learning, independent study, projects, inquiry, experimentation, and problem solving,
- the research-based shifts in mathematics and science education and the implications of these shifts on classroom instruction.

Because learning builds on prior knowledge and experiences, teachers make it a point to find out who their students are as individual learners and as a group, then use this knowledge to help shape decisions in the classroom. Practically everything about the learner is relevant to teachers including cultural, linguistic, and ethnic background, family setting, interests, needs and goals. The teachers strive to gain a sense of each student's degree of confidence in engaging in inquiry, his/her background knowledge, and individual facility with language.

In addition to their knowledge of students as individual learners, teachers also have a broad knowledge of learning characteristics and the developing capabilities of the age group. Teachers:

- recognize that, while students come to school with a wide range of experiences and ideas, for the most part they are intellectual novices engaged in building a mental picture of how the world works,
- are aware of the misconceptions students typically bring to a topic,
- understand that student learning proceeds from concrete experiences to abstract explanations and that direct experiences with natural and technological phenomena help students make useful generalizations about them,
- know that the vast majority of young learners cannot understand abstract models that explain the totality of scientific or mathematical knowledge on a given topic without a long-term building towards such understanding based on concrete experiences,
- know what level of thinking to expect from their students.

Pacific region teachers also understand the rich cultures in which their students live. They appreciate and act upon the fact that:

- although most educational activities are conducted in English, it remains a second language for many students;
- an understanding of the cultural traditions and values helps to inform the design of effective tasks and activities;
- an understanding of mathematical and scientific traditions embedded in the culture can be used to build educationally effective tasks;
- an understanding of the relationship between language and learning is useful in developing and using effective teaching strategies that engage students in learning mathematics and science;
- decisions about grouping, ways of responding to questions, displaying knowledge, ways of reporting learning, and group leadership are often critically important and culture-specific.

Standard 4:
ORCHESTRATING A VARIETY OF LEARNING TASKS

Effective mathematics and science teachers orchestrate a variety of tasks that promote problem solving, active learning, and making connections to other disciplines.

Tasks are what the students do either in class or in conjunction with class work to learn mathematics and science. Tasks can be projects, problems, investigations, exercises or applications. Tasks provide the context for the students' mathematical and scientific development. Good tasks develop knowledge and skills and demonstrate their usefulness.

Like a song leader or band director, highly accomplished teachers understand how different aspects of the learning environment contribute to the music of learning. They orchestrate learning—select and adapt instructional resources, including technology, laboratory and community resources, and create their own tasks to engage students in active explorations of mathematics and science. They use different teaching strategies at appropriate times to facilitate learning. They also use a variety of assessment techniques to gather information on the performance of students.

Teachers who are good learning facilitators select, adapt and create worthwhile tasks and materials that provide opportunities for students to build mathematical and scientific understandings, competence, interests, and habits of mind. They:

- select, adapt, and generate worthwhile tasks based on three areas of concern: the content, the students' learning needs, and the ways in which students relate those tasks to other life experiences,
- include tasks that foster students' abilities to solve problems, to reason, and to communicate mathematically and scientifically,
- strongly consider the developmental and cultural appropriateness of concepts and procedures associated with the tasks,
- offer students the opportunity to choose from a variety of sources, including mathematics and science problem booklets, computer software, calculators, puzzles, manipulatives, and textbooks,
- are responsive to students' varied learning styles, cultural perspectives, and points of view,
- encourage creative thinking and expression and the development of oral and written communication skills,

- pose questions that seek divergent and evaluative thinking rather than memory recall,
- view assessment of student learning as an integral part of the instruction.

Teachers who are skilled learning environment managers shape and direct students' opportunities to engage meaningfully in the learning process. Learning is best facilitated when teachers create and manage flexible, diverse, and rich classroom environments. They:

- create a "community for learning,"
- include and share learning responsibilities with families and the community and its resources,
- foster student leadership and peer teaching,
- help students affirm and develop respect for individual differences,
- instill in students confidence that they can learn mathematics and science and develop motivation in being independent, responsible, and persistent learners,
- organize and manage the classroom by doing long-range task analyses, troubleshooting problems for student learning, defining clear rules and expectations for students, establishing a system to make students responsible and accountable for both their academic work and behavior, and continually monitor and keep students apprised of the appropriateness of their work and behavior.

Standard 5:
CURRICULUM PLANNING AND DEVELOPMENT

Effective mathematics and science teachers are active participants in the ongoing planning and development of the mathematics and science programs and their relationship to the overall school curriculum.

It is important that teachers are involved in curriculum planning and development because they are the key to implementing what is expected. Because of their direct, daily interaction with students, teachers are the ones who are most aware of and sensitive to students' needs. Therefore, teachers are in the best position to make recommendations for reviewing and revising the curriculum. Effective teachers are ready to adapt changes and seek ways to make improvements in the curriculum. They are able to engage in:

- long-range planning to establish broad goals for their mathematics and science programs that are part of and reflect an overall school plan or scope and sequence,
- mid-range and daily planning to elaborate the particular activities in which students engage.

The planning process of an effective teacher is an interactive one. While engaging in this process, teachers:

- plan lessons that are designed to meet the students' needs in learning the content,
- use in the planning their analysis of what actually takes place in class,
- revise plans for future lessons based on classroom experience,
- engage in an ongoing cycle of planning, implementation, and revision,
- assess whether a particular program meets the needs of their students, school district, or community,
- are open to making needed improvements or modifications.

In their role as curriculum coordinators, teachers make decisions about what and how students will learn. They coordinate and develop the curriculum which defines learning objectives, organizes learning experiences, and develops assessment strategies.

Teachers function as curriculum coordinators when they:

- participate in committees choosing among and working to influence the content of different published programs,
- are involved as curriculum designers for themselves or their school system,
- decide on curriculum content to implement for themselves or for the school system,
- work with other teachers to plan interdisciplinary learning experiences.

Effective teachers are dedicated to the growth of mathematical and scientific literacy of all students. The teachers focus on big ideas in curriculum planning rather than on transmission of disconnected facts. And they provide instruction based on direct experiences that allow students to construct deep understandings of the major ideas of mathematics and science.

Standard 6:
A COMMUNITY OF LEARNERS

Effective mathematics and science teachers foster the building of communities of learners where mathematics and science are viewed as valuable ways of knowing that connect to other disciplines and stimulate students' disposition to learn.

This standard focuses on the social and intellectual environment that must be in place in the classroom if all students are to succeed in learning mathematics and science and have the opportunities to develop the skills and disposition for lifelong learning. Elements of this standard appear in other standards. They are brought together here to highlight the importance of the community of learners and what teachers do to foster its development.

A community of learners is one in which students develop a sense of purpose and the ability to assume responsibility for learning. For this to occur, students must be given opportunities to participate in:

- setting goals,
- planning activities,
- assessing their work,
- designing the learning environment.

As teachers provide these opportunities they require students to assume responsibility for a significant part of their own learning, the learning of the group, and the functioning of the classroom community.

A fundamental aspect of a community of learners is the communication or discourse that takes places. Effective communication requires:

- a foundation of respect and trust among individuals,
- development of the ability to engage in presenting evidence, reasoned argument, and explanation,
- structuring activities so that students are required to explain and justify their understandings and critically assess and challenge the explanation of others.

One of the assumptions of the Pacific standards is that all students should learn mathematics and science and that all are capable of full participation and making meaningful contributions to classroom learning. The nature of

the classroom community in which students learn mathematics and science is of critical importance to realizing this assumption. To do this, teachers:

- display and demand a respect for valuing the ideas, activities, and needs of all students,
- give students a significant voice in decisions about the content and context of their work and require students to take responsibility for their own learning and the learning of all members of the classroom community,
- nurture a collaborative approach to the work of the classroom community,
- model and emphasize the methods, habits of mind, and attitudes of inquiry.

Teachers demonstrate a respect for the ideas, activities, and thinking of all students through what they say and do, as well as through the flexibility with which they respond to students' interests, ideas, strengths, and needs. Whether adjusting an activity to reflect cultural background, providing resources for a small group to pursue an interest, or suggesting that an idea is valuable but cannot be pursued at the moment, teachers constantly model what it means to respect and value the views of others. Teacher actions go beyond modeling. They include:

- explicit teaching of respect,
- willingness to confront openly the inevitable times when expressions of disrespect, stereotyping, and prejudice emerge in the classroom.

In promoting the development of learning communities, effective teachers provide students with opportunities to:

- challenge their thinking and that of others for its significance and relevance to the subject,
- build support for their own and other students' improvement,
- become better decision makers,
- learn responsibility to community and self,
- develop the habits of mind, skills, and attitudes appropriate to mathematical and scientific inquiry, including collaboration and cooperation, invention and application, hypothesizing and testing, and ongoing decision making.

Communities of learners do not emerge spontaneously. They require careful support from teachers.

Standard 7:
MATHEMATICS AND SCIENCE FOR ALL STUDENTS

Effective teachers create a learning environment that ensures the participation of all students, fosters high expectations, and provides the means by which all students grow academically, socially, and ethically.

In creating an environment that provides all students with equal access to mathematics and science education, effective teachers:

- respond sensitively to human differences and build on individual strengths,
- include all students in mathematics and science activities and work to ensure their full participation,
- believe that every student can succeed and expect each student to work hard,
- acknowledge those who are reluctant to participate,
- persist in inviting those who are reluctant to participate.

Effective mathematics and science teachers know and value their students and build on the strengths of all students. Such teachers:

- acknowledge that every student comes to school with a unique set of experiences, personal history, and knowledge of the world,
- use examples from their students' culture, community, and home environment to constantly demonstrate the relevance of science and mathematics in students' daily lives.

Effective mathematics and science teachers are careful to monitor the participation of students in groups, making sure all have an equal opportunity to participate in questioning, verifying, investigating, planning, and decision making. Such teachers:

- realize that language itself can be a barrier to participation in mathematics and science activities,
- take steps to ensure that those students with language difficulties have full access to the curriculum, by using direct experiences with materials, manipulatives, ideas, and concepts to build and expand their students' vocabulary and language in a meaningful context,
- help all students find ways to participate in group discussions,
- are strong advocates for students who need special accommodations to participate fully in classroom activities,

- help each student gain confidence in participating, therefore providing an experience on which to build more challenging involvement.

The quality of classroom interactions is important in creating a productive learning environment. To foster positive interactions, effective mathematics and science teachers:

- deliberately promote a classroom environment that is lively and inquiry-based where students play active roles as mathematicians and scientists,
- work diligently to create a learning environment that is congenial and supportive and in which students feel safe to take risks,
- help students to understand that they may disagree with one another's ideas while remaining friends,
- model the idea that problems or experiments that do not turn out as expected are not viewed as failures, but rather as opportunities to learn.

Effective mathematics and science teachers create and maintain a productive learning environment through their organizational decisions and their managerial skills. Such teachers:

- understand that student conduct is largely a function of student engagement and that when students are interested in what they are doing in school, the learning environment becomes self-governing,
- involve students when setting classroom rules,
- establish orderly and workable learning routines that maximize student time on task and let students know what is expected of them,
- make instructional grouping decisions that create high expectations for all,
- are equally comfortable using whole class, cooperative grouping, one-on-one peer coaching, or other clustering arrangements, depending on the instructional purpose,
- are efficient classroom managers who know the value of using scarce resources creatively, take advantage of opportunities to acquire free and inexpensive materials, and are able to improvise and create materials when none are readily available.

Perhaps most central to the process of creating a favorable learning environment is the personal example teachers set in their own behaviors in the classroom and beyond. They are friendly and curious, enthusiastic about their interest in mathematics and science, and receptive of each student's contributions to the learning process. They are good listeners who are open to new ideas and have a healthy sense of humor. They are genuinely caring and respectful of all students.

Standard 8:
PROMOTING DISCOURSE

Effective mathematics and science teachers promote discourse that encourages and accepts the use of multiple modes of communication to build understanding.

Classroom discourse is central to the teaching and learning of mathematics and science. It reflects not only what students learn but how they learn it. Discourse is comprised of all the ways of representing, thinking, talking, agreeing and disagreeing that the students and the teacher engage in. Effective mathematics and science teachers focus on issues related to discourse, such as:

- Who talks? About what? In what ways?
- What do people write and record? In what ways?
- What questions are asked and who asks them? Who answers them?
- What makes something true or reasonable?
- How is it determined whether an idea makes sense?

Effective mathematics and science teachers help their students use a variety of forms of discourse, including oral, written, pictorial, symbolic, and graphic. In addition, they:

- provide students the opportunity to gain experience using many different tools that enhance discourse, such as computers and calculators, physical models, manipulatives, and other formal and informal methods of representation,
- recognize that some modes of communication may not be accessible to students and take steps to encourage and nurture students' efforts to develop new means of expression.

The teacher's role is to advance and organize classroom discourse in ways that foster student learning. They:

- encourage students to make ideas and conjectures public so that the teacher can assess the ways in which learners are making sense of things and students can reflect on the reasonableness of the ideas,
- give students the opportunity to communicate their thinking in the various modes that are natural for them.

Effective mathematics and science teachers help students express their ideas. They:

- have students work in collaborative/cooperative groups, giving students many opportunities to interact with their peers, to listen to and react to others, and to clarify explanations of their own thinking,
- ask questions that provoke students' reasoning about the problems they encounter and challenge students to think by giving them opportunities to elaborate on their ideas,
- take care not to dominate the discussion, edit or restate students' ideas, but instead allow other students to comment on, question or disagree with each others' statements.

In orchestrating classroom discourse, teachers are sensitive to students' needs and know when and how to provide the support that is sometimes necessary to move the discussion along. They:

- decide which ideas to probe and what connections to make,
- know when to provide more information and when to hold back,
- know when to allow a question to remain unsolved and when some sort of closure is necessary.

Effective mathematics and science teachers monitor students' participation in classroom discourse. They:

- involve every student in discussions,
- make sensitive decisions about whose turn it is to participate and take care not to call only on students who seem to have the correct answer,
- model the respect for diverse ways of thinking they want their students to use in responding to different ideas,
- give students appropriate wait time to think without feeling pressure from others who might be able to respond more quickly,
- accept a variety of ways for students to contribute to the class' thinking.

Standard 9:
VARIETY OF ASSESSMENT

Effective mathematics and science teachers use a variety of on-going assessment strategies as sources of information to enhance the learning and teaching of mathematics and science.

Assessment of students and of teaching, both formal and informal, provides teachers with data to make the many decisions that they must make as they plan and conduct their teaching. Assessment data also provide information for communicating about growth and achievement with individual students and with parents, other teachers, and administrators. The Pacific standards for assessment provide detail about the nature and uses of assessment. This standard highlights the relationship between teaching and assessment.

On-going assessment is an integral part of the teaching and learning process. It enables teachers to adjust instruction to meet the particular needs of each individual student and directs the learning process toward achieving desired outcomes. Teachers may use many strategies to gather and interpret the large amounts of information about students' understanding of mathematics and science that is present in thoughtful instructional activities. Classroom assessment may take many forms including:

- observing and listening to students as they work individually and in groups,
- discussing their ideas and conceptions as part of classroom discourse,
- interviewing students,
- student-created products such as investigative reports, written reports, pictorial work, models and inventions,
- formal performance tasks,
- examining portfolios of student work,
- paper and pencil tests.

Each mode of assessment has particular strengths and weaknesses and is used to gather different kinds of information about student understanding and skill development. Effective teachers choose the form of assessment in relationship to the particular learning goals of the class and students' experiences.

Analysis of student assessment data provides teachers with knowledge to better meet the needs of each student. It gives indications of students' current conceptions, the nature of their thinking, and how students know what they know. Teachers use this information to make decisions about:

- individual student-teacher interactions,
- modifications of learning activities to meet diverse student needs,
- the design of learning activities that build from student experience, culture, and prior understanding.

Effective teachers also assist students in formulating and constructing self-assessments. This process provides teachers with additional perspectives on student learning, deepens students' understanding of subject matter and its applications, and develops students' ability to assess and reflect on their own learning and accomplishments.

Teachers also model self-assessment and reflection. They approach their own teaching with a spirit of inquiry, continually seeking to understand which plans, decisions, and actions are effective in helping students and which are not. Effective teachers assess, reflect on, and learn from their own practice.

Effective mathematics and science teachers:

- systematically apply the Pacific standards for assessment,
- use a variety of assessment methods,
- assess knowledge, skills, and values reflected in the *Pacific Standards for Excellence in Mathematics* and *in Science*,
- assess reasons behind students' answers,
- recognize the importance of teachers' observations and judgments in the assessment process.

Standard 10:
REFLECTIVE LEARNERS

Effective mathematics and science teachers are reflective learners constantly analyzing, evaluating, and strengthening their practice in order to improve the quality of learning experiences for all their students.

Reflective teachers interpret the events that occur in the course of their teaching practice and monitor the effect of actions taken as well as the thought processes used to make decisions for future actions. John Dewey described such reflection as behavior which involves active, persistent, and careful consideration of any belief or practice in light of the grounds that support it and the further consequences to which it leads.

Teachers who reflect on their own practices, value thinking, and emphasize depth over breadth of coverage are able to consider alternative viewpoints on teaching and learning issues. They:

- analyze classroom anecdotes and reflect on the implications of their analysis for their students' experiences,
- keep a record of their present learning experiences,
- continually reflect on and develop their own sense of what constitutes change in their classroom.

Reflective teachers examine their own practices with questions such as:

- What is the mathematical or scientific purpose for doing this activity?
- What concepts will the activity develop or strengthen?
- What decisions do I need to make about grouping, resources, and time?
- How can I best introduce a new idea?
- What can I do or say to encourage student exploration?
- How can I adapt tasks to better ensure learning by all of my students?
- What guidance should I give to help students summarize and generalize their understandings?
- What questions, observations, and tasks can I use during and after instruction to assess student learning?
- If we use this process or content, what is the long-term effect on students' values, and therefore on society?

When teachers regularly engage in such reflections, their classrooms tend to have a measurable climate of thoughtfulness.

Standard 11:
INVOLVING FAMILIES AND COMMUNITIES

Effective mathematics and science teachers actively work with families and communities as partners in the education of their students.

Effective mathematics and science teachers know that the expectations and actions of families have a great impact on the learning success of their students. They realize that families are the students' first teachers and acknowledge that most families have high expectations for their children's education.

In fostering partnerships among schools, families, and communities, teachers:

- establish communication via newsletters, meetings, and other home and community activities essential to building the trust that will support the students in school,
- seek opportunities to pursue collaborative efforts between the school and home that are essential to the student,
- address mutually important issues of health and safety and provide information for assistance from local support groups in the community.

Effective mathematics and science teachers form partnerships with parents in supporting student success. In so doing, they:

- encourage quality time at home and school for follow-up and continual support,
- provide home/school projects that will engage student learning and activate critical thinking,
- gather information about students' strengths, weaknesses, interests, aspirations, and lifestyle.

Teachers who actively seek ways to work with families and communities:

- incorporate and interpret local cultural events into the mathematics and science programs,
- connect knowledge and experiences from home to school and vice versa,
- learn about the expertise and interests of family and community members who can contribute to mathematics and science learning in

all settings in order to help students make connections between in-school and out-of-school learning.

Effective mathematics and science teachers are aware of their membership in the community and how their actions communicate what they value. Through their example they help foster in their students a similar sense of community responsibility.

STANDARD 12: PROFESSIONAL GROWTH

Effective mathematics and science teachers actively seek and participate in professional growth opportunities for themselves and their colleagues and contribute to the professional growth programs of their respective professional organizations.

Exemplary mathematics and science teachers, as active members of the school and other educational associations, work to strengthen the school as a learning community for students, teachers, and others interested in education.

Effective mathematics and science teachers contribute to the improvement of the school's instructional program and collaborate with curriculum specialists, teachers, and other professionals to:

- decide on the curriculum content, scope and sequence, teaching strategies, and instructional materials to implement in their school,
- adapt mathematics and science content to meet the interests, knowledge, skills, and needs of their students,
- ensure that students with special needs have positive mathematics and science learning experiences,
- provide resources for their colleagues in other disciplines and collaborate in planning and designing curricula,
- make decisions concerning the allocation of time and resources to the mathematics and science programs.

Effective mathematics and science teachers advance the knowledge and practice of their colleagues at the school and beyond. In so doing, they:

- design and carry out professional activities in mathematics and science, including mentoring preservice and novice teachers,
- observe and provide feedback on the instructional approaches of colleagues and, in return, welcome their peers in their classrooms and laboratories,
- put on demonstrations of successful practices, organize workshops, and recommend particular workshops and courses that would improve their content knowledge and teaching strategies and those of their colleagues.

Highly effective mathematics and science teachers take active roles in their own professional organizations in a variety of ways. They may:

- contribute to and participate in their meetings, conferences, and seminars whenever possible,
- work collaboratively with colleagues in other areas and confer regularly with supervisory staff about their teaching and staff developmental needs.

Professional mathematics and science teachers are aware of the work of their local, state, or national education organizations and share the responsibility for strengthening the efforts of these organizations to accomplish the goals envisioned in these standards.

The mediocre teacher tells.

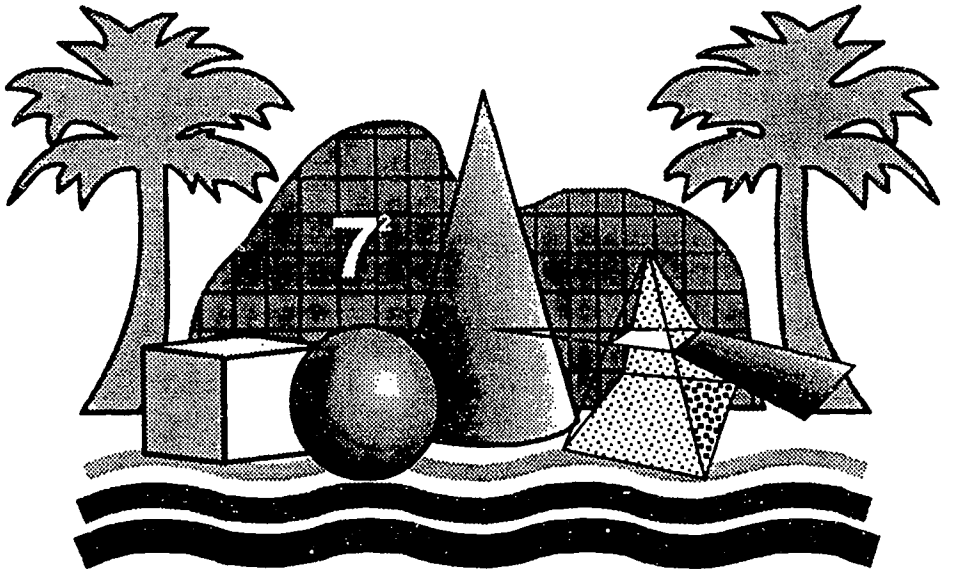
The good teacher explains.

The superior teacher demonstrates.

The great teacher inspires.

--William Arthur Ward

PACIFIC STANDARDS FOR ASSESSMENT



Pacific Standards for Assessment

1. Reflecting important mathematics and science
2. Using assessment to enhance learning
3. Honoring culture
4. Providing opportunities for success
5. Creating a climate of openness
6. Making valid inferences
7. Ensuring consistency and coherence
8. Evaluating the quality of student work
9. Checking the alignment of external assessments with valued outcomes

Introduction

Assessment is the process of collecting, synthesizing, interpreting and communicating information about individuals or groups of learners to acquire an understanding of their learning and help them continue to grow. Assessment helps educators answer questions about students' learning. For example: *What do my students know about the science within Pacific navigation? Do my students appreciate that mathematics is found all around us? Are they able to make connections between science and mathematics? Do my students have effective problem-solving capabilities? How skillful and accurate are their observations? Do my students' work show the persistence, curiosity, open-mindedness, and ability to pose questions that are critical to both mathematical and scientific literacy? Do my students' attitudes and actions demonstrate care and respect for others, our culture and our island environments?* Each time educators seek to answer questions concerning the components of mathematics and science literacy, they are assessing learning. Quality assessment provides a variety of ways for students to show their understanding of mathematics and science by answering questions as part of the instructional process in the classroom.

Assessing the complex outcomes defined in the *Pacific Standards for Excellence in Mathematics* and *in Science* involves clear purposes, well-defined learning targets, and criteria that describe the key qualities of fine work and can be used to evaluate the current level of student performance. Gathering useful information about student work also involves the use of multiple forms of assessment that match the learning targets. Before valid inferences can be made about learning, there must be multiple samples of student work related to major outcomes. Assessments should also be free from biases that can mask learning.

Quality assessment is intended to inform teaching and learning. Assessment provides opportunities for students to communicate their learning with teachers, parents, and others. Assessment also provides teachers and other educators with the information and opportunity to communicate with students, parents, and the community about student learning. This communication gives all concerned parties a deeper insight and provides feed forward for progress toward the vision that all Pacific children become scientifically and mathematically literate: knowledgeable, capable, and caring.

The story on the next page, **A Glimpse into Ioanis's Classroom**, presents a composite picture of a classroom where quality assessment has come to life. It provides a context for the assessment standards that follow. In Ioanis's classroom, activities are built around the big ideas in the Pacific standards; the teaching engages students in constructing understanding; and tasks and activities help students gather information, expand and apply their knowledge, and create records of their learning. The classroom activities portrayed provide students with opportunities to learn and to display that learning in a variety of ways, using criteria developed collaboratively by the teacher and students. Following completion of the projects, the students and the teacher have an opportunity to reflect and provide feed forward to enhance current work and future learning experiences.

ASSESSMENT

A Glimpse into Ioanis's Classroom

It is October and Ioanis, an eighth grade teacher, is about to begin a unit of study on electrical energy. He plans to build much of the unit around a visit to the power plant. The field trip will provide a context for the conceptual understandings the students are developing, and will also serve as a starting point for investigating the impact of electricity on the daily lives of the community.

To help them identify and build on their existing knowledge, Ioanis encourages his students to create concept webs around two questions: 1) What do we already know about electrical power? and 2) How has life changed since electrical power became readily available? In collaborative groups, students use the webs as the starting point to brainstorm questions and to develop strategies for answering them. In addition to helping the students focus their thinking, the webs provide Ioanis with valuable insights about students' thinking that he can use in planning his instruction. Similar webs created at the end of the unit will show how knowledge and understanding have grown, and will provide Ioanis and his students with valuable assessment information.

Ioanis decides to have the students write wall stories—displays created and hung on the classroom wall—as a way of organizing ideas and presenting them to others. Ioanis had developed wall stories during an intensive workshop the previous summer, but had never actually used them as a teaching and assessment tool in the classroom before. He talks with his class about wall stories and they all agree that the displays would work well as a way of reporting about the visit to the power plant. Since this was everyone's first experience with wall stories, Ioanis sets aside time to work with the class to identify criteria that describe effective wall stories. After a little uncertainty, and with a few examples and probing questions from Ioanis, students begin to list ideas for what makes a good wall story. The class quickly agrees that "content" and "organization" are important. After further discussion the students agree that it is also important for the parts of the display to work together to tell a story and "communication" is added to the list of criteria. When the discussion ends, three criteria are agreed upon. Ioanis and the students all think that if the criteria work well this time, they can be used for other wall stories in the future.

A group of students agree to make the following criteria chart for the classroom wall:

CONTENT:	The science content in the story is accurate and gives important information about the topic.
ORGANIZATION:	The wall story is organized and sequenced to tell the story.
COMMUNICATION:	The parts of the display support each other, and the story can stand alone and communicate about the topic without additional explanation.

It is now a few weeks later and the students have examined the information they collected during their visit to the power plants. They have the findings of the investigations carried out to answer the questions identified during the brainstorming at the beginning of the unit. Their wall stories can be seen around the room. On the walls are student-created graphs showing changes in power use in the community over the last five years, decreases in the average cost of electrical power as the plant's capacity increased, and reports that tell the story of changes in family and community life due to the availability of electrical power. Students presented their draft projects to each other and to a few visitors who were also present. It is now time to look at all the stories around the room, compliment each group on the work they have done, and make suggestions about how to make it even better.

This is called "feed forward"—helping each other to improve. To do this, students are using the criteria established earlier, their own knowledge of electrical power, and their communication skills. To honor their culture and avoid the difficulty of directly telling other students of weaknesses in their work, students have chosen to write their compliments and suggestions in project journals rather than do an oral review. They are making positive comments about parts of the work that meet the criteria, such as:

- *"Your drawings really show the details of how things work. When I see them, they make me remember important ideas that we learned at the power plant."*

- (example of feed forward on how to make the wall story better) *"I like the clear and interesting drawings, but sometimes the story doesn't match what's in the drawing. It would help to have the words directly connected to the drawing."*

Each group will consider its own reflections and the comments others have written in the journal in order to finish the wall stories and prepare for the formal evaluation. As the review ends, the classroom becomes very quiet, and each student is amazed at the work the class has accomplished and the individual contribution each of them has made. The students are proud of their learning.

Ioanis steps aside as the groups make final improvements on their work and prepare to present them to their parents that evening. Several students are placing arrows on a chart showing connections between their recent work and the major concepts and expectations of the 8th grade curriculum. Others are rehearsing opening remarks to the parents which will highlight their achievements. As the students wrap up their work, Ioanis reflects on how much teaching and assessment have changed these last few years. No longer the "knower of all things," he has encouraged students to take the lead in their own learning and be responsible for producing evidence of the progress they have made. He is grateful for the professional development opportunities which enabled him to make the changes. The partnership has expanded more this year to include family and community and both Ioanis and the students proudly wait for this evening's event. He feels good about his classroom, the students in it and their families. He smiles as he anticipates the bright future of his students and Pacific education in general.

This brief look into Ioanis's classroom provides one view of quality assessment in action. The standards that follow describe the key ingredients of quality assessment. They focus on classroom assessments, the kinds of assessments that take place in the midst of instruction and are an integral part of student learning. These assessments are closely connected to instruction, involve immediate feed forward to help students improve their work in progress, and are designed to provide rich, detailed pictures of individual students' learning. The following beliefs form the foundation for the Pacific assessment standards:

1. Every student can learn and is capable of achieving mathematical and scientific literacy; assessments need to help educators see the development of that literacy clearly.

2. Children must have opportunities to learn how to respond to a variety of types of assessment so that their assessments truly show their knowledge, capabilities and caring.

3. Assessment should help students become reflective learners—to develop skills and confidence as self-assessors.

4. Assessment is an integral part of teaching and learning—good assessment produces learning and improves teaching.

5. There are multiple ways of learning and assessing learning. Assessments need to have clear purposes and the types of assessment used must match the purposes.

6. Assessments should portray learning. To do this, assessment tools must be fair, unbiased, challenging, flexible, and authentic.

7. Instruction that prepares students to portray their learning does not teach to the test, rather it is teaching to the standards.

8. The results of assessments must be used for the intended purposes and should never be used to punish, ridicule, or threaten students.

9. Assessment information needs to be clear and understandable to the users—students, teachers, school administrators, parents, community members, and others.

Standard 1:
REFLECTING IMPORTANT MATHEMATICS AND SCIENCE

Quality assessment focuses on and establishes clear expectations concerning the mathematics and science that are most important for students to learn.

The *Pacific Standards for Excellence in Mathematics* and *Pacific Standards for Excellence in Science* describe the knowledge, capabilities and values that are essential for literacy. Quality assessment reflects these and other standards and focuses on the big ideas of the respective disciplines rather than on bits and pieces of information. The quality assessment of complex outcomes, such as habits of mind, connection making, and the ability to communicate learning requires time and a variety of assessment tools.

Quality assessment is clear about what to assess, and students know what is expected of them. Clear learning expectations lead to assessments that provide useful insights into students' growth toward mathematical and scientific literacy. The assessment process is a learning and communication process in which the assessors—teachers, students, parents, administrators or others—learn about what students know and can do, and students learn about what the assessors value. Students also learn about their own progress and about themselves as learners.

Quality assessment reflects important mathematics and science in:

- the plans for assessment and instruction,
- the assessment tasks and activities,
- the interpretation of students' responses,
- the intended uses of the assessment results,
- the criteria used to describe and/or score students' responses.

The assessment of each student's mathematics/science learning will be valued by the student, parents, teachers, and the public, if it presents a comprehensive view of important concepts and processes. These assessments involve thinking and problem solving, investigating and applying students' capabilities to complex mathematical, scientific and human issues, and provide valid insights into student learning. Plans for assessment focus on gathering evidence of progress as well as attainment of levels of performance. They include the assessment of all aspects of being knowledgeable, capable, and caring.

The use of a variety of assessment tools provides a more complete picture of the knowledge, skills, and attitudes of students. While paper and pencil tests may reflect students' knowledge base, performance assessments are appropriate to gather information about their ability to apply what they know. Quality tasks:

- center on important understandings,
- connect to the classroom curriculum and are built on contexts that are familiar to students,
- lead to further thinking, questioning, probing, and problem solving,
- are thought-provoking and challenging, and help students value the outcome,
- connect ideas and skills together rather than focus on small bits and pieces of information,
- often offer multiple paths to carry out the task,
- model good instruction—students learn while showing what they can do and how well they can apply knowledge and skills to new situations,
- encourage students to show their learning in a variety of ways,
- often include opportunities for students to reflect on and evaluate the quality of their work and progress over time.

Quality assessment provides results focused on the important mathematics and science students have learned and are doing. In quality assessment, the interpretation of responses is based on clear expectations and on established criteria that have been shared with students. These criteria identify the key qualities of an excellent response and communicate to students what is valued. Quality assessment gives students alternatives in demonstrating learning progress. The results are most useful if they are presented in simple terms that everyone, including the students, can understand. Assessment is a portrayal of student learning, with measurement as just one way of gathering information about that learning. Assessment results should be used to inform teaching and advance student learning.

Standard 2:
USING ASSESSMENT TO ENHANCE LEARNING

Quality assessments are imbedded in instruction, providing experiences and insights that enhance student learning and improve teaching.

Quality assessments are an integral part of classroom instruction, not an interruption. Assessments enhance learning when they cause students to think and act on their knowledge and capabilities. They provide students with experiences and insights and teachers with information to improve and better focus instruction.

Quality assessment enhances learning by:

- utilizing learning tasks that enable students to construct meaning,
- being an ongoing and integral part of instruction,
- providing ongoing feed forward to students and teachers,
- providing information that is used to improve instruction,
- involving students in thinking and reflecting on their learning,
- recognizing the powerful impact assessments have on students' beliefs in their own ability to learn and improve.

Quality assessment tasks enable students to apply prior knowledge and learning to new situations. In constructing lesson plans and in making instructional decisions, effective teachers identify and plan opportunities for assessments that will benefit students and teachers. Insights gained from assessments provide valuable information that can be used to make decisions about teaching and improve learning.

Quality assessments provide students with an opportunity to reflect on their work and progress, to understand what they know and are able to do, to have confidence in their ability to learn, and to determine what they have yet to learn. As a result of assessments, students make decisions about whether they can learn, whether they should continue to try, and what they are capable of learning. Students often make significant decisions about their future based on assessment information. The power of assessment to affect students' beliefs in their ability to learn must be recognized. Quality assessment, based on a variety of tools, provides students with accurate self-portraits enabling them to confidently and accurately look at their futures.

Standard 3:
HONORING CULTURE

Quality assessment incorporates and honors culture and includes the rich mathematics and science found in the Pacific islands.

Quality assessment enables students to value the knowledge they bring from home and their culture, build on what they know, feel confident about their ability to become mathematically and scientifically literate, and create detailed portraits of their learning. This is accomplished by providing opportunities for students to communicate about their learning in their most fluent language, ensuring that tasks reflect contexts familiar to the students, and by endorsing a variety of ways of demonstrating learning.

The interaction of culture and assessment offers opportunities for rich portraits of student learning. Effective teachers use in their classrooms, assessments that are designed to incorporate students' cultural background to enrich the resulting portrait of learning. When designing assessments, teachers ensure that mismatches of language, mores, and other cultural attributes that can mask learning are avoided.

To inspire learning and build toward success for all, quality assessment:

- builds on and honors culture,
- minimizes cultural biases that hide learning,
- demands intellectual quality,
- does not limit the challenge of the tasks,
- encourages diversity in the ways that learners can show what they know, are able to do, and care about.

Clearer portraits of learning result when assessments build on and honor the culture of learners. The assessment process honors and incorporates culture when:

- assessment includes the mathematics and science found in Pacific cultures,
- the ways of knowing and showing learning within Pacific cultures are acknowledged and valued,

- assessment measures learning across multiple intelligences, including the body-kinesthetic, spatial, and musical intelligences which are prominent in many Pacific cultures,
- cultural implications of questioning by young people are recognized and distinctions are made between questioning to learn and questioning to challenge authority.

Questioning is a central part of assessment, and teachers encourage students to ask questions as part of developing mathematical and scientific literacy. However, the meaning of questioning within cultures is very significant. Questioning elders, especially by young people, is inappropriate in some cultures. In the Pacific, effective teachers lead students and families to understand the value of appropriate questioning and to make careful distinctions between questioning to learn and questioning to challenge.

To gather accurate portraits of student learning while honoring Pacific cultures, quality assessment:

- enables students to use the language in which they are most fluent to express their learning,
- includes group as well as individual performance tasks,
- recognizes that brief responses that synthesize the heart of a mathematical or scientific concept can be as excellent as elaborated oral or written responses.

When assessment builds on the life experiences of the students—mathematics, science and culture—learning is enhanced and enriched. These quality assessments:

- provide clear, detailed images of student learning in the areas valued within and across cultures,
- include tasks in which students can see their own culture(s), their environment, and the important mathematics and science therein,
- provide opportunities for students to discover examples of the essential knowledge, capabilities and caring identified by the Pacific Standards in their own cultures,
- provide students with opportunities to express learning in the language of their choice.

Standard 4:
PROVIDING OPPORTUNITIES FOR SUCCESS

Quality assessment provides all students with opportunities for success.

Quality assessment provides opportunities for success by focusing on the ideas, habits of mind, and capabilities that students have learned. It gives students opportunities to demonstrate their knowledge, capabilities and attitudes in a variety of ways.

Quality assessment ensures all students opportunities for success by:

- providing all students expectations for success,
- providing all students opportunities for choice,
- supporting each student's opportunity to learn important ideas involving higher-order thinking, and continues their progress in developing mathematics/science literacy,
- adapting assessments for learners with special needs,
- providing practice and experience using multiple forms of assessment,
- providing students with opportunities to display their learning using a variety of response options.

Quality assessments provide students with a variety of ways to demonstrate their learning. These assessments reflect a belief that all students can succeed and provide avenues for success to occur. They do not function as gatekeepers that prevent some students from access to important mathematics/science. Quality assessments enable students to create rich self-portraits that enhance self-image, lead them to recognize their abilities, and encourage them to continue learning and growing.

Striving for success for all means that assessment activities and tasks are adapted to overcome, or minimize, the limitations of students with special needs and provide appropriate options for response. Quality assessment tasks consider student needs in the presentation of the tasks and in response options, while continuing to be challenging and focused on important mathematics and science.

For quality assessments to provide occasions for students to excel, students are given opportunities to understand and practice using various of forms of assessment as part of the instructional process. This practice is intended to help students learn to respond effectively by using a particular form of assessment and to provide the feed forward necessary for improvement.

Standard 5:
CREATING A CLIMATE OF OPENNESS

Quality assessment processes are open to review and scrutiny.

Assessment processes are open when teachers are involved in the planning and designing of tasks, when students know what they are expected to learn and how they will be expected to show their learning, and when parents are partners in conversations about their children's learning. The climate of openness is further enhanced when the purposes and uses of assessment are communicated to all involved.

In an open assessment process:

- teachers are involved in all aspects, from planning and designing the assessment to making inferences about student learning,
- performance standards are openly developed and shared,
- students know the criteria for quality and how they will be expected to demonstrate growth toward the standards,
- parents are partners in conversations about their children's learning.

Quality assessment programs involve teachers in all aspects of assessment design, implementation and interpretation. Effective teachers create a climate of openness in assessment by including students, parents, colleagues, and others in planning and developing assessments. In instances where external assessments are used, teachers are aware of the focus of those assessments and take part in the interpretions of results. Open assessment engages teachers in collegial groups to look at student work across classrooms and schools to gain a clearer understanding of common learning targets and criteria, therefore improving the assessment process in their individual classrooms.

Quality assessment involves students in the development of criteria used to assess their performance. This enables students to become skillful assessors of their own work and to set learning goals based on their performance. Students understand the expectations and the nature of assessments that will be used to portray their learning. Sharing sample assessments and scoring rubrics with students is part of an open assessment process and aids students in the development of a deeper understanding of assessment.

ASSESSMENT

Parents are important partners in quality assessment. Assessment information is used by parents to judge their children's progress and is the basis for many other important decisions, such as whether to encourage their children's aspirations for post-secondary schooling, celebrate their children's learning, or demand improvement. Assessment information also shapes parents' opinions about teachers and the overall quality of the school program.

Ongoing communication with parents is a key component of a quality assessment program. Teachers and students assume responsibility for sharing the learning with parents and family. This communication is clear, open, and inviting, providing opportunities for parents and family to be involved in their child's learning. In addition to teachers, students and parents, openness in assessment invites the involvement of the community as partners in the assessment and improvement of the educational process.

Standard 6:
MAKING VALID INFERENCES

Quality assessment leads to valid inferences about student learning.

Quality assessment leads to valid inferences and a clear and accurate picture of learning. An inference about learning is a conclusion about a student's cognitive processes that cannot be observed directly. The conclusion is based instead on the student's performance. Many potential sources of performance are available. Mathematics and science assessments include evidence from observations, interviews, open-ended tasks, extended problems and investigations, portfolios and exhibitions, as well as more traditional paper and pencil forms of assessment, such as multiple-choice and short-answer tests.

Valid inferences about learning are promoted when:

- the purpose of assessment is clear and known to students,
- the learning outcome is clearly defined in expectations about essential knowledge, capabilities, habits of mind and values,
- multiple forms of assessment are used as sources of evidence about learning and are appropriate for the purpose of the assessment,
- there is a sufficient sample of student work to provide quality evidence that is adequate and relevant to the outcomes,
- teachers are knowledgeable about assessment and their professional judgment about the quality of student work is based on well-defined criteria,
- biases that threaten validity have been eliminated or minimized,
- students have alternative ways for communicating their learning.

A quality assessment process informs students of the expectations for success in mathematics and science—as defined in the *Pacific Standards for Excellence* and local performance standards—and ways in which they are expected to demonstrate their learning.

Because single assessments often yield an incomplete or inaccurate picture, quality assessment utilizes multiple samples of student work to get a valid picture of student learning. Multiple assessments enable students to show their understanding through a variety of learning styles and engage more than a single intelligence. This variety allows for weaknesses in one assessment to be compensated by strengths in others, resulting in a more

detailed and complete picture of mathematical and scientific literacy and leading to valid inferences about student learning.
The existence of biases in the assessment process masks learning and leads to inaccurate portrayals of students and classrooms. Quality assessments are carefully designed so that context, language, culture, gender, preconceptions on the part of the teacher, and other factors are not allowed to interfere with fair and accurate judgments about student learning. Such designs ensure that assessment leads to fair and valid inferences about learning. In the Pacific region, language often inhibits response. Quality assessment is carried out in the language of instruction at a level matching the language development of the students and is designed so that language is not a barrier to displaying learning.

New forms of assessment require increased attention to procedures for making valid inferences about the mathematics and science that students know, can do, and care about. Assessments based on a framework of important mathematics and science, draw on multiple sources of evidence, minimize bias, and support student learning in providing the evidence needed for valid inferences.

Standard 7:
ENSURING CONSISTENCY AND COHERENCE

Quality assessment connects curriculum, instruction and assessment and shows consistency among purpose, process, and reporting.

Quality assessment is designed to ensure consistency across assessment, instruction, and curriculum. It provides insight into the learning of important mathematics and science in the classroom. Quality assessment provides consistency among purpose, process, and reporting. The kinds of assessments used, the interpretation of student work based on criteria, and reporting about learning are consistent with the learning outcomes defined in the curriculum. The teaching directly supports students' development of those outcomes.

Quality assessment shows coherence and consistency by:

- employing assessment designs that match the purposes of the assessment, the curriculum, and the instruction so that they form a coherent whole,
- utilizing a collection of assessment instruments, tasks and criteria that are designed to accomplish the purposes,
- establishing and making judgments based on criteria that identify the key qualities of a successful performance,
- using forms of reporting that are related to the purpose of the assessment and that give valid, useful and clear information about student learning.

A process that connects content standards, instructional practices, and assessment tools is useful in providing coherence and consistency. This process provides a basis for the selection/development of appropriate and diverse assessments that match educational purposes and uses. The process also provides teachers with a perspective that allows them to design classroom instruction that meets the intended learning outcomes and prepares students for the assessment.

Quality judgment of student performance on mathematics/science tasks is based on criteria that are directly related to the key qualities of a successful performance. These criteria are the basis for communicating about learning with students and others. A relatively fixed set of criteria for tasks aimed at the same big ideas and capabilities helps students

understand the assessment process, improve their work, and increase opportunities for success.

Matching process to purpose and relating these to reporting is a critical part of assessment. For example, when the purpose is to provide a coherent and valid profile of student growth in mathematical and scientific literacy, assessment evidence from performance tasks, student projects, interviews and open-ended questions, investigations, and exhibitions can be used in addition to traditional paper and pencil tests. The assessment process includes interpreting, organizing, and communicating information. Quality reporting is consistent with the purposes of the assessment and makes valid inferences that are consistent with the assessment instruments used and, where possible, informed by the framework on which the curriculum and the instruction is based. The traditional report card is insufficient to communicate coherently about the complex outcomes that represent mathematical and scientific literacy. Reporting about students' growth literacy creates a coherent portrait of learning through narratives, student-led parent conferences, parent examination of actual samples of student work, student self-assessment and goal setting, and the use of continua that describe common characteristics of developing literacy.

Standard 8:
EVALUATING THE QUALITY OF STUDENT WORK

Quality assessment used to evaluate learning includes clear and open criteria for making judgments about the quality of student work.

Evaluating the quality of student work is an essential part of assessment. Evaluation is based on quality assessment when worthwhile tasks are carried out and judged according to clear criteria that are known to students and which can be used by them to improve the quality of their work prior to evaluation. Evaluation must focus on student work, and not on the personality or other personal characteristics of students.

Quality assessment leads to accurate evaluation when:

- there are clear criteria that focus on the important elements of a successful performance,
- it focuses on the work itself and how it compares to agreed-upon descriptions of an excellent performance,
- there is common understanding among teachers and between teachers and students of what quality work looks like.

Clear criteria are at the heart of the evaluation that results from quality assessments. Effective teachers use agreed-upon criteria to give feed forward as students grow in their understandings and work toward evaluative assessment. Criteria used to assess learning and growth are powerful descriptions that define quality performance. These criteria help students make choices, assess themselves, and discover areas for improvement. Criteria are often developed collaboratively by groups of teachers or by teachers and students. They are then used systematically to improve student work. Such criteria are used:

- by the teacher to assess student work,
- for student self-assessment so that students can monitor their own progress, achievement, and growth in a given area and then set goals,
- as the basis for students' self-reflections on the quality of their work,
- to help students expand their thinking and understanding related to a given content area,
- as a springboard from which students develop and apply their own criteria, thereby expanding their personal vision of what it means to be successful.

ASSESSMENT

Because quality assessment provides opportunities for success by all students and provides them with opportunities to demonstrate excellence, effective teachers use the information obtained through assessment in a non-judgmental way to talk with students about the current status of their work and encourage them to continue improving the quality of their products. This view of assessment values learning as an ongoing developmental process. Students know what they are working toward and can use the assessment information to adjust and improve their work.

Standard 9:
CHECKING THE ALIGNMENT OF EXTERNAL ASSESSMENTS WITH VALUED OUTCOMES

External assessments support important mathematics and science learning by reflecting desired learning outcomes and are consistent with internal practices.

External assessments contribute to a quality assessment process and enrich the understanding of student learning when they are consistent with the curriculum goals, instructional practices, and assessment design used in the school setting.

External assessments are valid and contribute to quality assessment processes when they:

- are aligned with the school curriculum,
- are consistent with classroom instructional and assessment practices,
- add to the knowledge gained through classroom assessment.

External assessments are developed outside the classroom, such as district, state, and commercial assessments. Often, the purpose of these assessments is to help decision makers outside the classroom get clearer pictures of student learning across a grade level, a school, or many schools. Judgments based on external assessments are valuable resources when looking at school improvement and program effectiveness, but often they do not accurately reflect individual student achievement.

External assessments contribute to a quality assessment system when their goals, objectives, and desired mathematical/scientific outcomes match those of the school and classroom. The usefulness of such assessments is increased when classroom work, teacher judgments, and student reflections are valued as part of the external assessment process.

Thoughtful decisions to use an external assessment are based on the:

- usefulness of the information gained from the external assessment to enhance learning and teaching,
- alignment of the external assessment with curriculum and instruction,
- ability of the asssessment to provide important evidence that cannot be gathered in other ways.

ASSESSMENT

Assessment and the Vision for Pacific Students

To assess the scientific and mathematical literacy of all Pacific students, today's assessments need to examine not only the basics of the past, but also each student's ability to think critically, analyze, investigate, and make inferences. These complex skills are at the heart of the Pacific Standards. As expectations for students' achievement in mathematics and science expand, additional forms of assessment are required.

Quality assessment furthers the achievement of scientific and mathematical literacy. Quality assessment:

- is an ongoing process linking student growth in learning, classroom instructional practices, and information gathered for decision making,
- communicates to students the mathematics and science (knowledge, capabilities, and values) principles that are important,
- supports the continued mathematics and science learning of each student,
- is nonjudgmental and provides feed forward,
- enables teachers to have better understanding of their students,
- enables parents to have a clearer understanding of their children's learning,
- enables parents to play a greater role in the schooling of their children as they participate in the assessment process.

Quality assessment provides opportunities for students to:

- reflect and evaluate their own progress and learning,
- take responsibility for their own learning,
- engage in critical and creative thinking,
- develop high self-esteem,
- understand the key characteristics of quality work,
- compare the current level of their work with standards of excellence.

Quality assessment of student learning leads to changes in many components of education systems, including:

- teacher preparation,
- resource allocations,
- program characteristics,
- policies.

Standards in Action: A Hawai`i Story

The following classroom story from Hawai`i illustrates assessment as a part of instruction. In the story, students work in collaborative groups, use a variety of mathematical skills and multiple intelligences, and communicate ideas in ways that demonstrate evidence of their learning.

Keoni dropped the M&Ms on his desk looking for two pieces of data: the number of M&Ms in his package of candy, and the number of red M&Ms. The three other students in his group watched intently, then began to follow the same procedure with their packages. Keoni proudly announced he had 10 red candies out of 32. Karen answered with 8 out of 36. Miss Terri asked the question: "If the M&Ms from each person's package were mixed up and put back in the package and then only one M&M was drawn, which person in your group would have the best chance of drawing a red candy and why?"

The search was on! Methods were discussed, charts and diagrams were made. Explanations were written. Miss Terri circulated among the groups listening for students' comments, asking questions when necessary to probe and extend students' thinking. Encouraging participation by all group members, she observed students' behavior and kept notes relating to student contributions to their group. She was aware of the productive ways students chose to reach their goal. Presentations to the class followed with the groups showing several ways to answer the questions. From the discussion and presentations, additional questions were raised about comparison of fractions and probabilities. Miss Terri planned to use these questions to begin class the next day. After school, Keoni beamed as Miss Terri discussed with his mother the contributions he made to his group and the class.

—contributed by Jeanne Nelson, Kamehameha Schools, Honolulu, Hawai`i

Purposes of Assessment

The primary purpose of assessment is to clearly and accurately create a complete and coherent picture of learning. Assessments are also used to help teachers, administrators, parents, and community members make careful decisions about learning and teaching. Some uses of assessment information are to:

1. document achievement,
2. guide learning,
3. provide information for grading,
4. plan teaching,
5. portray student progress,
6. make comparisons of strategies and methods,
7. determine access to special or advanced education,
8. develop educational theory,
9. allocate resources,
10. evaluate the quality of curriculum.

Because assessment is used in making critical decisions about learning and teaching, one of the first questions educators need to ask and answer when planning for quality assessment is its purpose. Pacific mathematics and science educators responded to questions concerning the purposes and uses of assessment as follows:

What do we want our assessments to do for our students?
Our students should:

- be able to self-assess,
- expand their critical and creative thinking,
- become productive citizens,
- be responsible for their own learning,
- understand what is important,
- reflect and evaluate their own progress and the quality of their work,
- become empowered and self-assured,
- be assured that they all have equal opportunities for their education,
- be helped to see themselves realistically,
- believe that they can learn.

What do we want our assessments to do for teachers?
We want our teachers to:

- focus on depth in the curriculum,
- become better listeners and observers,
- know their students well,
- self-assess what they are doing,

- become more thoughtful and reflective thinkers,
- use assessment as information to improve instruction.

What do we want our assessments to do for parents and family?
We want parents and families to:

- have clearer perceptions of their children's learning,
- increase communication about learning with their children,
- actively participate in the learning and assessment process,
- increase communication with the school,
- take a greater role in schooling.

We do not want our assessments to:

- focus on comparing students against each other; instead, students' work should be compared against performance standards,
- stop learning, limit or lower self-esteem,
- pressure teachers to teach to the test,
- force or encourage teachers to spend too much time on test preparation,
- narrow students' access to important mathematics and science,
- limit curriculum to easily assessed knowledge and skills.

Types of Assessment

The mathematics and science knowledge, capabilities, and values to be assessed will determine the types of assessment used. For example, to answer the question, "What do my students know?" all three major forms of assessment can be used: paper and pencil, performance assessment and personal communication. When the assessment question is, "How well can my students apply what they know and extend their knowledge?" educators need to select forms of assessment that enable them to get clear pictures of the students' capabilities, such as mathematical reasoning, critical thinking, problem solving and scientific inquiry. Various forms of assessment provide different kinds of information about student learning. The tasks and activities educators use to gather assessment information about complex learning are frequently open ended—having many quality answers. To get a rich, deep view of student problem solving and thinking, educators need to design tasks that require students to think and problem solve in complex, real-life situations. The following table illustrates how various types of student outcomes link with various forms of assessment:

Type of Student Outcome	Paper/Pencil tests	Performance Assessments	Personal Communication
Knowledge	X		X
Capabilities		X	
Thinking	X	X	X
Products		X	
Caring	X	X	X

Additional Thoughts About Culture and Assessment: Critical Questions

Examining the interaction of culture and assessment is important to ensure that children have the opportunity to create rich portraits of their knowledge and capabilities. During planning and implementation of assessments, fundamental questions should be asked and answered about culture. Although specific questions can vary from culture to culture, the following are intended to prompt discussion about cultural factors that affect students' ability to clearly communicate their learning and educators' ability to interpret the quality of their work.

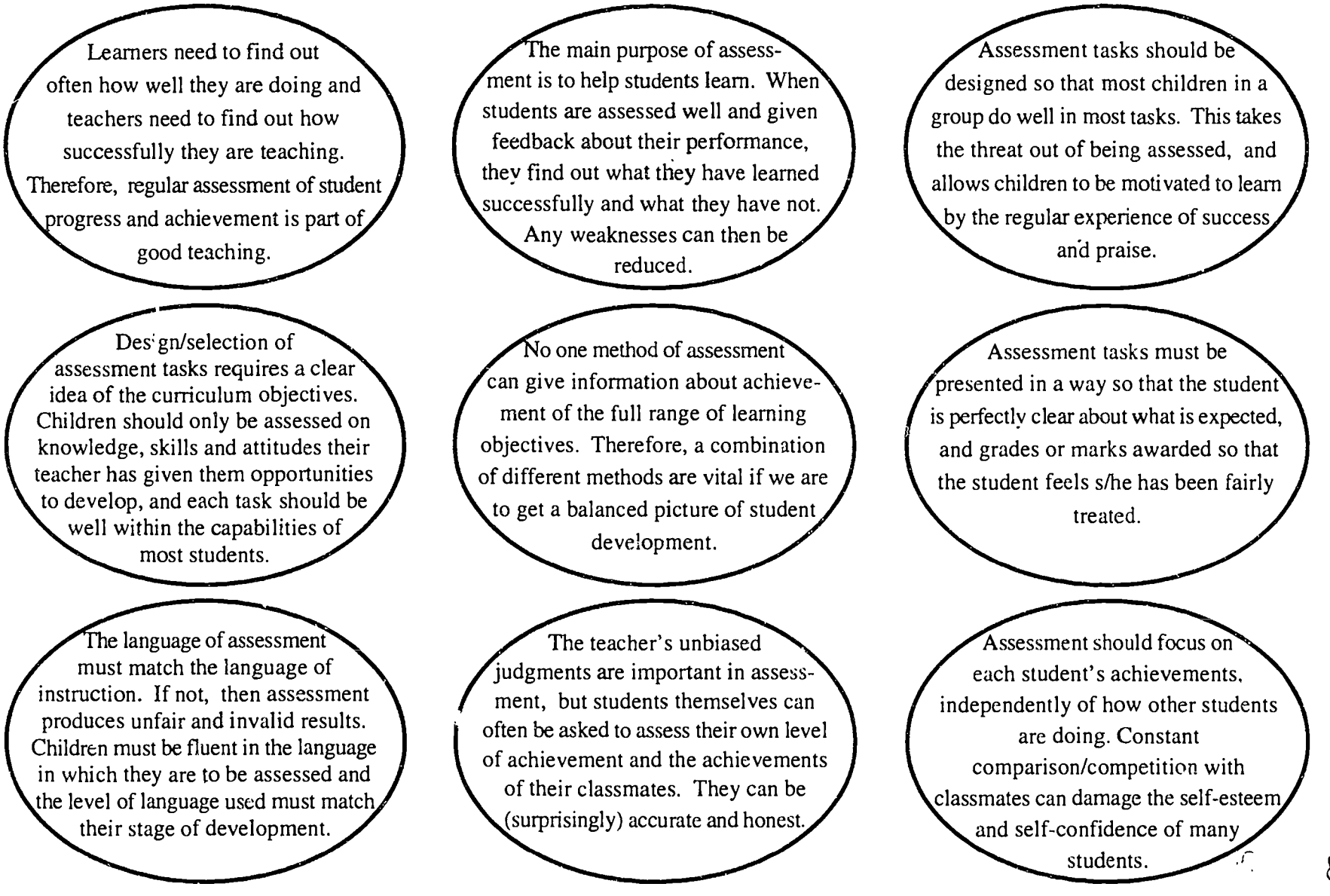
Assessment Questions	Related Questions and Issues
What is worth ... knowing? doing? caring about?	What knowledge, skills and attitudes are essential ... across cultures? within a culture?
	To what extent should "universal" knowledge take precedence?
	What is the community's vision for the future of its children?
	How is what is "worth knowing" determined within the culture? Who determines?
	What are the essential skills and habits of mind across cultures?
	What knowledge, skills, cultural practices, and values from within the students' culture should be assessed?
	Whose role is it to provide knowledge from within the culture? To what extent should schools be involved?
	How do we develop quality assessments for deep cultural knowledge? What language or languages should be used? Who must be involved? To what extent can schools be involved without usurping authority in the culture?
	To what extent is knowledge "owned" in the culture? What implications does this have for making the knowledge overt through instruction and assessment?

ASSESSMENT

Assessment Questions	Related Questions and Issues
What are the purposes of assessment?	What do teachers want assessments to do for them? For their students? For parents? Who are the key receivers of assessment information in the culture?
How can students be prepared to display vivid images of their learning?	What are powerful metaphors and parables of learning and assessment in the culture? Are visual images useful? Does the culture value oral expression? What are the communication patterns and preferences? To what extent should assessment honor those patterns? To what extent and at what level(s) should assessment tasks require students to stretch themselves beyond their comfort level?
How will we know they are learning?	What are appropriate ways for children to display their learning in the culture? What language will assure students opportunities to truly display their learning? What assessment purposes require the use of students' home language? A second language? To what extent should assessments require students to be multicultural? Is self-reflection a universal habit of mind? Is the revealing of self-reflection to others appropriate? Or is it more related to personality? What are the key differences and similarities between the culture of the home and community and the school culture?

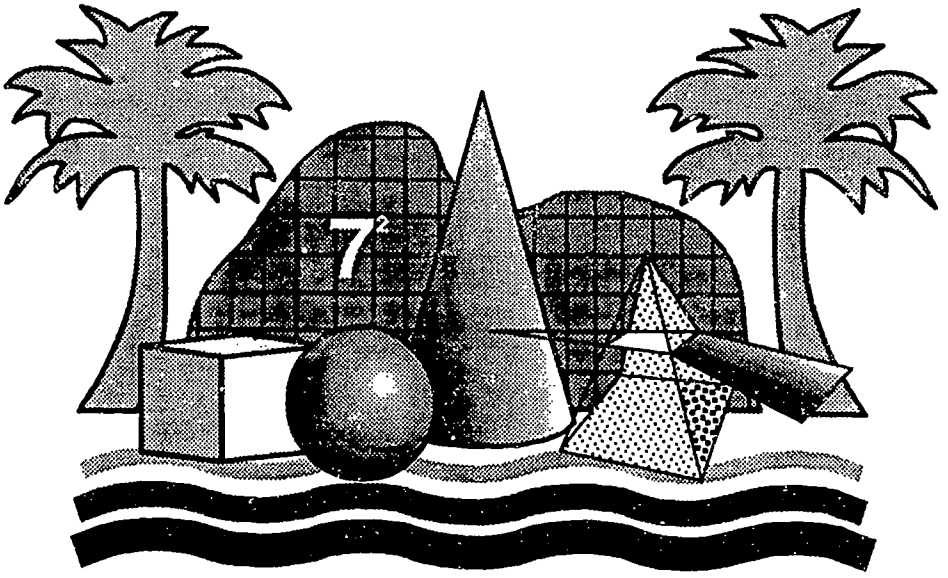
Assessment Questions	Related Questions and Issues
What is a quality assessment task?	Should tasks be "culture free"? How much context is essential? Should we begin with local context and then design tasks that require knowledge of other cultures? What kinds of tasks are common in the culture? Is the culture one that emphasizes high-context communication? What are implications for assessment? For gauging the quality of students' work? Who can work together in a group? Who cannot be in the same group? Will grouping by gender help or hinder?
Do you see what I see?	Are perceptions of quality the same across cultures? What are indicators of quality in the culture?
How should students be given feedback about the quality of their work?	What are appropriate forms of feedback in the culture? Is individual, public feedback viewed as positive? Very negative? Is non-public individual feedback effective? Acceptable? Is group feedback effective? Written feedback? Who can give feedback? Who cannot? Is peer assessment acceptable? Is feedback in the culture focused on the strengths of the work? Or is it focused on weaknesses? Do children from a culture that provides negative feedback respond to positive feedback?

Figure 1: FASE Assessment Principles



From the FSM/Australia Science Education (FASE) project. These principals emerged during a 1993 workshop with teachers and administrators.

PACIFIC STANDARDS FOR PROFESSIONAL DEVELOPMENT



Pacific Standards for Professional Development

1. Experiencing good teaching

2. Knowing mathematics and science

3. Understanding students as learners

4. Building pedagogical knowledge

5. Developing as teachers

6. Engaging teachers in the professional development process

7. Designing professional development programs

Introduction

The professional development of mathematics and science teachers is similar to the development of other professionals. There should be times when teachers can observe and talk with master teachers; can study the latest research on teaching and learning; can reflect on their own teaching performance, and do their own action research to help every student achieve and learn mathematics and science. The process of becoming effective mathematics and science teachers is a continuing, lifelong one that extends throughout their careers. Teachers constantly need to build up their knowledge and skills base, because science and mathematics are disciplines that are rapidly changing and have great significance in the lives of people and their world. As practitioners, learners, and researchers, teachers become more effective as they keep abreast of and contribute to the development and refinement of new approaches to teaching, assessment, and curriculum.

These professional development standards are adapted from the National Council of Teachers of Mathematics *Professional Standards for Teaching Mathematics* and the National Research Council *National Science Education Standards, Draft Version*. These standards are intended to assist all people with roles in planning, developing, and delivering professional development to teachers of mathematics and science at the preservice and continuing education levels. Because the standards assume that professional development is continuous, there is no attempt to separate standards for prospective teachers and standards for practicing teachers. Professional development needs to be coherent and collaborative. Therefore, teachers, schools, districts, departments of education, institutions of higher education, and other service providers must work together to encourage coordinated teacher development programs.

Along with the standards for mathematics, science, teaching, and assessment, the professional development standards for teachers in these two disciplines focus on a vision of mathematical and scientific literacy for all Pacific children and constitute an effort to improve mathematics and science learning in classrooms across the region. Therefore, opportunities for teachers to extend their knowledge and skills must be clearly and appropriately linked to their work in the school. If this vision is to be achieved, the professional development of science and mathematics teachers must include the development of the knowledge, skills, understandings and attitudes reflected in the *Pacific Standards for Excellence Series*.

Standard 1:
EXPERIENCING GOOD TEACHING

The effective professional development of teachers requires learning content through viewpoints and methods consistent with the *Pacific Standards for Excellence in Mathematics* and *in Science*. Mathematics and science learning experiences for teachers should provide opportunities for them to examine, reflect on, and revise their beliefs about the nature of mathematics and science.

Teachers are greatly influenced by the teaching they see and experience. Their learning experiences have a powerful impact on the education they provide their students. Prospective and practicing teachers spend many hours in courses, workshops, seminars, and other structured learning environments. As a result of these experiences, they form ideas and beliefs, and develop techniques that contribute to their evolving vision of what mathematics and science are, how they are learned, and how they should be taught.

Instructors in preservice and inservice programs, both in the disciplines and in education, model good mathematics and science teaching by:

- emphasizing and valuing important mathematics and science concepts and posing worthwhile activities that build on the teachers' current knowledge, skills, and attitudes,
- engaging teachers in mathematical and scientific discourse and use of a variety of tools, including laboratory equipment, calculators, computers, physical and pictorial models,
- creating learning environments that support and encourage mathematical and scientific reasoning and inquiry; and dispositions and abilities to do mathematics and science,
- encouraging reflection on the process and outcomes of understanding mathematics and science through inquiry and discourse,
- expecting and encouraging teachers to take intellectual risks in doing mathematics and science and to work both independently and collaboratively,
- demonstrating mathematics and science as ongoing human ventures,
- affirming and supporting full participation in and continued study of mathematics and science by all.

Content and education courses for both preservice and inservice teachers are effective when they address the major components of teaching—inquiry, reasoning, problem solving, communicating, learning environment, and analysis of teaching. This shifts the focus from content presented through lecture and demonstration to active participation and involvement. Mathematics and science teachers do not "teach" content; instead they help learners construct their own understanding of mathematics and science.

The shifts in mathematics and science education and the changing expectations placed on teachers call for substantial changes in the philosophy and strategies used in mathematics, science, and education programs. A wider range of tasks, tools, and modes of classroom interaction enables such a change. Collegial groups to share and model new instructional strategies assist in the change process. This type of instruction can help all learners experience mathematics and science as dynamic means to solve problems. Instruction organized around experiences that address issues, events, problems, or topics that contain important mathematics and science and are of interest to participants provides preservice and inservice teachers with a model to use in their own classrooms. Such instruction engages participants in searching for solutions to problems and provides continuing opportunities to talk about both mathematics and science.

Effective inservice programs at the district and school level also reflect these characteristics.

Standard 2:
KNOWING MATHEMATICS AND SCIENCE

Effective professional development provides all teachers of mathematics and science with opportunities to develop a broad understanding of content and a deep understanding of the specific concepts appropriate to their grade level. This understanding includes the ways of knowing, communicating, and the characteristic attitudes of the respective disciplines.

Knowledge of both the content and nature of mathematics and science is an essential component of teacher preparation. Teachers' comfort with and confidence in their own knowledge of mathematics and science affect both what they teach and how they teach. The knowledge, skills, and attitudes teachers develop as a result of their study of the respective disciplines shape their choice of worthwhile mathematical and scientific tasks, the kinds of learning environments they create, and the discourse in their classrooms.

Effective preservice and inservice education of mathematics and science teachers helps them develop their knowledge of mathematics and science, including:

- significant mathematical and scientific concepts and the connections among them—within each discipline and across disciplines,
- effectively conducting inquiry, reasoning, problem solving, and communicating,
- multiple representations of mathematical and scientific concepts and procedures,
- contributions of different cultures toward the development of mathematics and science,
- changes in mathematics and science and the ways educators teach, learn, and do mathematics and science because of emerging technology,
- school mathematics and school science within the disciplines of mathematics and science, their relationships to other school subjects, and their applications in society,
- skills enabling them to broaden their own understanding of mathematics and science.

The depth of understanding of mathematics and science required of teachers varies by grade level. Judgments regarding what constitutes

sufficient understanding should be tied to the expectations for students in their classrooms. Teachers should have an understanding of the respective disciplines deep enough to guide student inquiries, assess student learning, and further the achievement of mathematical and scientific literacy. Teachers must be able to use their knowledge of content, teaching, and learning to use student questions as a starting point to design and guide inquiry, so that students are able to make the conceptual connections necessary for intellectual growth.

This understanding is not developed in isolation. Learning to identify, define, and discuss concepts and processes, to understand the connections among them, and to appreciate the relationships of mathematics and science to other disciplines all take place at the same time. Effective teachers understand and use the techniques and perspectives of inquiry, reasoning, and problem solving. They are also able to communicate their understanding to others in a logical and accurate manner. A solid understanding of the content and the skills to conduct discourse lead teachers to greater confidence in their own abilities. There are common experiences that should be ingredients in the ways teachers of mathematics and science build and extend their knowledge. Regardless of the context, the following are prominent in these experiences:

- problem solving,
- communicating,
- reasoning,
- developing connections (both within the discipline and to their uses in the world around us),
- building the confidence to learn mathematics and science independently,
- developing and applying mathematical and scientific language and symbols,
- developing a view of mathematics as a study of patterns and relationships,
- perspectives on the nature of mathematics and science through a historical and cultural approach.

Developing abilities in reasoning and problem solving are essential to becoming skilled in doing mathematics and science. Reasoning involves an interplay between intuition, informal and formal exploration, and logical argument. The struggles, the false starts, and the informal investigations that lead to a reasonable solution are frequently missing. Opportunities to construct mathematics and science for themselves and to interact with others to pose and solve problems in order to develop

problem-solving strategies are an important part of professional development.

Central to the preparation for teaching mathematics and science is the development of a deep understanding of the mathematics and science in the school curriculum and how they fit within the respective disciplines. Opportunities to revisit school mathematics and science content in ways that will allow teachers to develop deeper understandings of the ideas and relationships that are involved between and among concepts are an important part of professional development. Such opportunities include developing broad understandings of significant mathematics and science concepts and how they are related to other parts of the curriculum. This includes opportunities to develop an overview of the mathematics and science curricula. At all levels, effective teachers see the big picture of their discipline across the elementary and secondary school years. Computers, communication, and other technologies have become vital forces in learning, teaching and doing mathematics and science. They provide new approaches for solving problems and influence the kinds of questions to be investigated, as well as the pedagogical strategies that enhance and extend mathematics and science learning and teaching. Understanding technology and its applications is a significant component of understanding the disciplines of mathematics and science in the school setting.

Standard 3:
UNDERSTANDING STUDENTS AS LEARNERS

Professional development should include the continual exploration of how learning occurs, how it can be facilitated, and how to provide environments and opportunities that are responsive to the needs of students.

Effective professional development programs, both preservice and inservice, integrate and incorporate current theories and research of the disciplines and the behavioral, cognitive, and social sciences as they relate to mathematics and science learning. A thorough understanding of the constructivist theory of learning, the diversity of learning styles present in every classroom, and the multiple intelligences within individual learners are critical pieces of the knowledge of learning that effective mathematics and science teachers possess.

Effective preservice and continuing education provides mathematics and science teachers with a deep and current understanding of students as learners by developing teachers' knowledge of:

- how students learn,
- the diversity of learning styles present in the classroom,
- the multiple intelligences within individual learners,
- the effects of students' age, abilities, interests, and experience on learning,
- the effect of culture on students,
- the influences of students' linguistic, ethnic, racial, and socioeconomic backgrounds and gender on learning mathematics and science,
- ways to affirm and support full participation and continued study of mathematics and science by all students.

The importance of teachers' knowledge of how students learn cannot be overemphasized. A thorough understanding of children's intellectual, social, and emotional development is critical to effective teaching. Such knowledge gives direction to the kinds of learning environments that teachers create, the tasks they select, and the discourse that they foster.

Skilled mathematics and science teachers have a solid understanding of their disciplines and of learning theories. Learning is an active, dynamic, and continuous process that is both an individual and a social experience. Effective teachers know that learners build a variety of perceptions as they learn. Some of these are confused or incomplete; others remarkably rich.

Teachers need opportunities to examine and anticipate children's thinking about mathematics and science, so that the they can select or create experiences that can help children develop their understanding. Developing multiple perspectives of students as learners enables teachers to build learning environments in which students can learn with appropriate support and acceptance.

Language and culture affect thinking and behavior. Language and its role in students' understanding of and doing mathematics and science need attention in programs for the development of teachers. Teachers' knowledge of their students' cultural backgrounds and the implication of this knowledge for their teaching is a crucial part of understanding students as learners.

The Pacific standards are based upon a vision that calls for mathematical and scientific literacy for all. Teacher expectations are founded on knowledge and beliefs about who their students are and what they can do. These beliefs and expectations often become barriers to achieving literacy for all. Teachers need knowledge about, and experience with, using a variety of strategies that allow and encourage all students to succeed in a heterogeneous environment. Professional development programs for teachers need to provide access to the literature that addresses the problem of involving all in the study of mathematics and science and identifies successful intervention strategies.

The inequities that are found in the classrooms are often subtle and not intentional, and yet they exist. Are there gender, cultural, or racial differences in a teacher's interactions with students in the classroom? Grouping of students, classroom climate, choice of materials, topics, activities, assessment, and teaching strategies all have impact on how effectively all students see themselves as involved members of the class. Teachers need help in learning to monitor classroom interactions, in order to reveal and remedy inequities of all kinds. Videotaping instances of positive and negative feedback, disciplinary and social interactions, listing names of students who do not and who do receive attention can provide insights into unconsciously biased behaviors. If inequities are identified, then strategies need to be developed to help a teacher address these concerns. Such strategies can be discussed in professional development activities for teachers. A genuine respect for and understanding of students as individuals and as participants in a learning community is essential to promoting experiences for all students in mathematics and science.

Context, as it relates to students' interest and experience, is important to learning. Children moving toward scientific and mathematical literacy

know how mathematics and science apply to the real world, to everyday life and how these subjects relate to other school curricula. The ability to recognize and include mathematical and scientific aspects of ethnic and cultural identity provides teachers with an additional tool to give students greater motivation for further study of the two disciplines. Connecting classroom mathematics and science to the community, the culture, and role models may motivate students toward greater participation in mathematics and science.

Standard 4:
BUILDING PEDAGOGICAL KNOWLEDGE

Professional development of mathematics and science teachers enables them to develop a broad repertoire of instructional strategies so that they can integrate their knowledge of content and learning with their experience to design instruction that meets the needs of students.

Effective mathematics and science teaching is more than knowing content and understanding students. Skilled teachers are able to integrate the two to create learning situations that match the needs of those in the classroom with the science and mathematics to be learned. Effective professional development provides teachers with this capacity.

Effective preservice and continuing education programs help mathematics and science teachers develop a knowledge of and the ability to use and evaluate:

- a variety of instructional materials and resources, including technology,
- different ways to represent mathematics and science concepts and procedures,
- a variety of instructional strategies and classroom organizational models,
- multiple ways to promote inquiry, reasoning, and problem solving, and foster a sense of community and collaboration in the classroom,
- a variety of means for assessing student understanding of mathematics and science as described in the previous section of this document.

Pedagogy in mathematics and science focuses on the ways in which teachers help their students come to understand and be able to do and use mathematics and science. Learning is a developmental process that takes time and is often hard work.

Effective teachers use a variety of forms of instruction that permit students to build their own mathematical and scientific knowledge and their abilities for posing, constructing, exploring, solving, and justifying problems and concepts. Promising models for such instruction are all highly interactive. In such models, teachers both demonstrate and elicit communication and thinking, facilitating learning rather than presenting faultless products and correct answers.

Effective professional development programs enable teachers to use strategies that will actively engage students in mathematics and science. By working in groups, students have an opportunity to verbalize their own understandings and to hear those of others and to reflect upon differences, challenging themselves by asking for reasons and accounting for their own thinking and reasoning. This process promotes deeper understanding and conceptual development. Another practice that supports students' participation involves shifting responsibility for control of learning from teacher to student by expecting students to make commitments to their work and answers.

Assessment has a central role in the effective teaching of both mathematics and science. Effective professional development programs prepare teachers to integrate the understanding and use of a variety of methods of assessment as an ongoing part of their educational life. The assessment standards presented earlier in this document describe assessment which will lead toward achieving the vision for Pacific children.

A deep understanding of the art of teaching is fundamental to the effective teaching of mathematics and science. Decisions about instructional materials are intimately associated with decisions about ways to represent mathematics and science concepts and ways of knowing. Choices for instructional strategies and classroom organizational models both evolve from and influence such decisions. Teachers' knowledge and their ability to use and evaluate these components in their own teaching develop over time. Growing professionally engages teachers in reflecting on and assessing their own efforts to promote inquiry, reasoning, problem solving, and communication in the classroom. This will enable them to know what works or does not work so that they can improve, enrich, and extend their instruction.

Standard 5:
DEVELOPING AS TEACHERS

The ongoing professional development of teachers enables them to develop understandings, skills, and behaviors that enable them to assess, reflect on, and learn from their teaching and thus improve their practices.

Teaching is a complex set of behaviors that requires constant learning and continual reflection on the whole process. The goal of teacher education is to provide direction on how to most effectively plan and teach mathematics and science. The reflective practice of teaching, a growing sense of self as a teacher, and the continual search for new and better ways to teach and learn help teachers focus as they strive to become more effective.

Effective preservice and inservice experiences provide mathematics and science teachers with opportunities to:

- examine and revise their assumptions about the nature of mathematics and science, how they should be taught, and how students learn mathematics and science,
- observe and analyze a range of approaches to mathematics and science teaching and learning, focusing on creating learning environments that support students striving to achieve the Pacific standards for mathematics and science,
- work with a diverse range of students individually, in small groups, and in large class settings with guidance from and in collaboration with other mathematics and science educators,
- analyze and evaluate the appropriateness and effectiveness of their teaching,
- develop and maintain interest in and excitement about teaching mathematics and science.

Essentially, being a teacher means developing a sense of self as a teacher of mathematics or science. Such an identity is built upon many different experiences with teaching and learning. It is reinforced by feedback from students, from colleagues who demonstrate professional respect and acceptance, and from a variety of external sources that demonstrate recognition of teaching as a valued profession. Confident mathematics and science teachers exhibit flexibility and comfort with mathematical and scientific knowledge and a commitment to their own professional

development within the larger community of mathematics and science educators.

The nature and kinds of teaching experiences that are part of the effective preservice and inservice education of teachers are varied and numerous. For teacher candidates, this involves opportunities to work one-on-one or with small groups of students, which permit them to focus on interviewing or micro-teaching. Preservice teachers have opportunities to work with exemplary teachers. As apprentices, they are supervised by teacher education faculty who know mathematics and science and are mathematics and science teachers themselves. These experiences are part of a sequential program that allows them to be in a variety of classroom settings for a variety of purposes and with increasing levels of responsibility. At least one of these experiences is long-term, under the guidance of a master teacher.

During the first few years, teaching is an intensely focused experience that centers on the students for whom the teacher is responsible and on the teacher's growing sense of self as a teacher. Beginning teachers often seek the advice and guidance of more experienced teachers. Colleagues and supervisors should act as both informal and formal resources for teachers at this stage of their professional development.

Experienced teachers have different needs. They have a general frame that surrounds their picture of teaching and they understand the nature of the learning process on a daily, weekly, and monthly basis throughout the school year. They are now better able to anticipate timing, overall organization and management, and student responses. Their repertoire of instructional methods and techniques has grown, and they often can successfully anticipate what works and does not work in the classroom. They engage in reflection and self-assessment, as well as interactions with colleagues and supervisors to improve their effectiveness. Good teaching ideas emerge during conversations with colleagues and supervisors who know mathematics and science and who have been successful in teaching these disciplines themselves. Colleagues who are knowledgeable about the content and pedagogical issues are valuable resources. An identifying characteristic of professional experienced teachers is a willingness to assist in the growth and improvement of their colleagues, both preservice and inservice.

Standard 6:
ENGAGING TEACHERS IN THE PROFESSIONAL DEVELOPMENT PROCESS

Effective professional development enables teachers to become active in establishing the school as a center of inquiry which supports their on-going professional growth as teachers.

Teachers' professional development, within and outside their classrooms, is a product of their willingness to reflect on their practice and participate in educational opportunities to enhance and extend their knowledge and understanding of their discipline, of teaching, and learning. As professionals, teachers take responsibility for their own growth and development and for the overall improvement of the education community. Support and encouragement of teachers by schools and school districts helps them accept these responsibilities.

As professionals, effective mathematics and science teachers take an active role in professional development by accepting responsibility for:

- building their knowledge, skills, and attitudes as bases for lifelong learning,
- experimenting thoughtfully with a variety of approaches and strategies in the classroom,
- reflecting on learning and teaching individually and with colleagues,
- participating in workshops, courses, and other educational opportunities in mathematics and science,
- participating as an active member of the community of mathematics and science educators at the local, regional, and national level,
- keeping current by reading articles, accessing research and discussing ideas in mathematics, science, and education,
- using their skills and knowledge to generate new knowledge about the disciplines and the teaching and learning of mathematics and science,
- participating in planning, delivering, and evaluating professional development for mathematics and science teachers,
- participating in school, community, and entity efforts to bring about positive change in mathematics and science education.

Effective teachers develop as professionals continuously throughout their careers. Focusing on their classroom practice, they may test a variety of approaches to engage students in mathematics and science, explore

possible strategies for assessment, and experiment with different ways of organizing the classroom. These teachers analyze and adapt strategies, examining their effectiveness in helping students develop understanding and confidence. Beyond the classroom, teachers also evolve as participants in a wider educational community. They read, talk with colleagues, engage the community, and take the initiative to press for improvement.

Teachers can take an active role in their professional development through such activities as:

- forming special-interest groups within their schools to investigate ways technology might better enhance their teaching,
- participating in summer programs to learn new topics,
- meeting with teachers from neighboring schools and entities to explore ways of working together to offer advanced courses for their students via telecommunications,
- working on curriculum renewal with other mathematics and science teachers to change the nature and kinds of courses,
- joining local associations, attending meetings, making presentations, and assuming leadership roles.

Professionalism among teachers is built through a support system that links them to colleagues inside and outside their particular schools. Teachers should be able to turn to colleagues for information on any aspect of mathematics and science education to expand their views of the disciplines, their resources for teaching, and their repertoire of teaching and learning skills. This interaction provides intellectual refreshment, and leads teachers to see their role as team players with input into and responsibility for the entire process of education.

Standard 7:
DESIGNING PROFESSIONAL DEVELOPMENT PROGRAMS

Effective professional development programs are coordinated, coherent, integrated, and focused on the vision of mathematical and scientific literacy for all Pacific children.

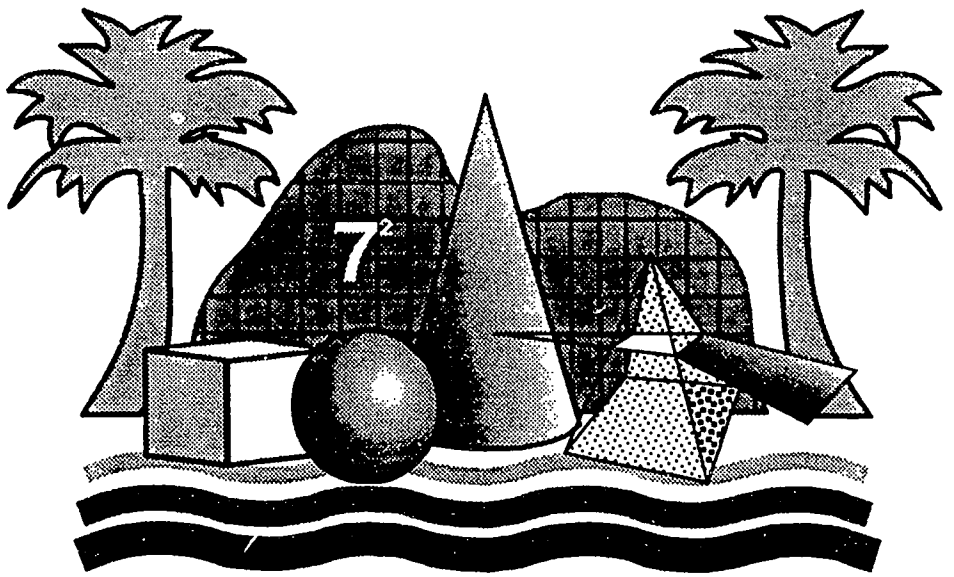
The integrated knowledge needed to effectively teach mathematics and science is developed over time. For this development to occur, it is essential for departments of education, schools, institutions of higher education, and other service providers to collaborate to design, plan, and offer coherent professional development programs that meet the needs of teachers throughout their careers.

Quality professional development programs for preservice and inservice teachers of mathematics and science:

- are coherent and integrated,
- have clear and shared goals compatible with the *Pacific Standards Excellence Series*,
- model the teaching and learning processes promoted throughout the *Pacific Standards for Excellence Series*,
- involve teachers in determining and meeting development needs,
- are ongoing with frequent reinforcement,
- are based on teacher needs, their varying experiences, and proficiency,
- respect the individuality of each educator,
- include regular periodic assessment of the program.

Traditionally, for most teachers, professional development has been a random, irregular collection of workshops, courses, seminars, and conferences. Teacher developers from all sectors must sit together to design activities and sessions to teach, enrich, and expand teachers' knowledge, skills, and understandings in mathematics and science in ways to help all Pacific children become mathematically and scientifically literate. To bring that design to life may take the efforts of the entire community: other teachers, administrators, college instructors, members of the immediate and world-wide community, and people from other professions.

APPENDICES



GLOSSARY

analytical trait scoring: a scoring procedure in which performances are judged and scored separately for separate criteria, traits or dimensions. An example is providing separate scores for important decisions of problem solving in mathematics like understanding the problem, selecting and using mathematical procedures, and communicating clearly what was done. Analytical scoring is especially useful when the purpose of assessment is to provide students with very focused information about the strengths of their work and ideas about which traits need improvement.

assessment: the process of collecting, synthesizing, and interpreting information about individuals or groups of learners, in order to understand their learning and to help them continue to grow.

benchmarks: examples of performances that serve as a standard against which other papers or performances may be judged.

classroom assessments: the assessments that take place in the midst of instruction and are an integral part of students' learning.

collaborate: to cooperate with, join together and participate; to work with each other to accomplish set goal(s).

communication: process of giving, sending, or exchanging thoughts, feelings, opinions, and information orally or in writing.

community of learners: students and teachers working together as a team to develop a sense of purpose and ability for learning.

conceptual connections: linking general and fundamental ideas needed to reason, problem solve, and/or create new knowledge.

constructivism: theory of learning that focuses on allowing students to make meaning for themselves through active learning experiences.

criteria: the key characteristics or qualities of fine work. They are used in rubrics and scoring guides to describe or as the basis for making informed judgments about the quality of student responses, products and performances. Other terms that are sometimes used are dimensions or traits.

criterion-referenced assessment: an assessment designed to show what a student knows, understands, or can do in relation to specific performance objectives. Criterion-

referenced assessments are used to identify student strengths and weaknesses. For example, "She typed 55 words per minute without errors." Criterion-referenced assessments focus on what each child has learned and assume that most students can achieve the objectives of the curriculum.

discipline: branch of learning/knowledge; field of study.

discourse: all the ways of representing, thinking, talking, agreeing, and disagreeing that students and teachers engage in. Discourse may take a variety of forms: oral, written, pictorial, symbolic, and graphic.

evaluation: making judgments about the quality of student work using information about learning gathered through assessments. Good evaluations of learning are generally based on multiple sources of assessment information.

facilitator: person who plans and leads instructional activities, yet lets the students still be responsible for their own learning.

feed forward: the process of using criteria to communicate about student work in progress so that it can be improved as it is developing. When a teacher or student gives feed forward, they describe the strengths of current work and raise questions or make suggestions based on the criteria. Feed forward takes place in the midst of learning rather than at the end.

grade: a grade is a symbol (traditionally a number or letter) that summarizes the level of student work.

habits of mind: values, attitudes, and skills that indicate a person's outlook on learning.

holistic scoring: a scoring procedure that results in a single summary score for the whole or a piece of student work. Holistic scores are based on an overall impression of a student product or performance. Criteria are used in holistic scoring but result in a single score or description that reflects the single level of performance.

inquiry: investigation and search for information and knowledge.

multiple intelligences: theory formulated by Howard Gardner to describe the broad range of capabilities used by humans in solving problems and creating things and ideas.

norm-referenced assessment: an assessment designed to show how a student's performance or test results rank when compared to the work of an appropriate peer group. Norm-referenced assessments assume that some students will do very well, some will do very poorly, and most will fall somewhere in the middle. Norm-referenced assessments focus on providing information about which child knows most and which knows least and how to rank the work of everyone in between.

orchestrate: arrange, coordinate, manipulate parts and elements to achieve an objective or goal.

paper and pencil assessment: an assessment that generally uses questions or test items that require students to select a response from choices that are given. Paper and pencil assessments use formats such as multiple choice, true/false, and matching. Another paper and pencil format which requires students to create a response is the short answer or fill in item.

pedagogy: the work of a teacher; the art and science of teaching; instructional methods and strategies.

performance assessment: an assessment based on direct observation of students' performances or products and involves using performance criteria to make judgments about the performance or product created by students. It uses assessment activities that require students to construct a response, create a product, or apply their knowledge and capabilities. Most performance assessments do not have a single correct answer and students can use more than one approach to complete the task. Good performance assessments consist of a learning task that students respond to and a set of criteria that guide scoring and feed forward.

personal communication: a form of assessment that uses oral questions and student responses as opportunities for assessment. It also includes interviews, student questions, and informal conversations.

reflective learning or **reflective teaching:** looking back at or reflecting on teaching/learning practices for the purpose of analyzing, evaluating, and strengthening the quality of learning experiences; reflecting on teaching/learning practices with a spirit of inquiry, continually seeking to understand which plans, decisions, and actions are effective in the learning process and which are not.

reliability: an indication of the consistency of scores across evaluators over time or across different versions of a test. For example, a test is reliable when different teachers or other evaluators give student responses the same or similar scores no matter when the assessment takes place or who does the scoring.

reporting: a process for communicating about student learning; preparing and presenting detailed accounts or statements about student learning. Grades are often used in reporting, but more recent trends in assessment have expanded reporting to include portfolio conferences, student self-assessment, exhibitions of mastery, narrative descriptions of learning, and developmental continua that show where students' current performance is in relation to common expectations.

rubric: a guide for scoring student performances and products. Rubrics are built from criteria that describe the characteristics of products or performances using a scale—descriptions or numbers that indicate levels of performance. For example:

1 point for *novice*, 2 points for *apprentice*, 3 points for *proficient*, 4 points for *distinguished*.

for young learners: 1 point for *just beginning*, 2 points for *on the way*, 3 points for *ready to share*.

Rubrics often include sample responses that show various points on the scale.

self-assessment and **self-reflection:** the process of having students look at their own work and apply agreed-upon criteria to judge the quality of their work. When students self-reflect, they think about their own learning and use both their thoughts and collections of their work as a mirror to look at their own strengths, weaknesses and overall achievement.

standard: a statement about what is valued that can be used for making a judgment or quality.

student-centered curriculum: a curriculum that takes into account what students already know to build and refine their understanding of new concepts.

technology: application of knowledge to develop tools, materials, techniques, and systems to help people meet and fulfill their needs.

validity: refers to whether an assessment measures what it is supposed to measure. For example, a valid assessment of mathematics problem solving would focus on the student's ability to solve problems and not on the ability to read the problem.

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OBTAINING MORE INFORMATION ABOUT THE PACIFIC STANDARDS

Further information regarding *the Pacific Standards for Excellence in Teaching, Assessment and Professional Development* and other documents in the *Pacific Standards for Excellence Series* can be obtained from:

The Pacific Mathematics and Science Regional Consortium
PACIFIC REGION EDUCATIONAL LABORATORY
828 Fort Street Mall - Suite 500
Honolulu, Hawai`i
tel: 808-533-6000
e-mail: askmathsci@prel.hawaii.edu

or the Mathematics and Science Leadership Team Members listed below:

AMERICAN SAMOA
Mr. Philo Jennings
Ms. Netini S. Sene
Division of Curriculum & Instruction
Department of Education
P.O. Box 3140
Pago Pago, AS 96799
Phone: (684) 633-1246

CNMI
Ms. Jackie Quitugua
Mr. Nicholas Sablan
Public School System
P.O. Box 1370
Saipan, MP 96950
Phone: (670) 288-0690/3/4

CHUUK
Mr. Aurelio Sauder
Mr. Sanfio Sony
Department of Education
P.O. Box 460
Weno, Chuuk FM 96942
Phone: (691) 330-2202/2475

GUAM
Ms. Teresita Mesa
Mr. John Simpson
Public School System
P.O. Box DE
Agana, GU 96910
Phone: (671) 475-0454/0452

HAWAI'I
Mr. Justin Mew
Ms. Kathleen Nishimura
OIS, GEB, Math & Science Section
189 Lunalilo Home Road, 2nd Floor
Honolulu, HI 96825
Phone: (808) 396-2567

Ms. Jeanne Nelson
Kamehameha Schools
Kapalama Heights
Honolulu, HI 96817
Phone: (808) 842-8351

KOSRAE
Gibson Mongkeya
Department of Education
P.O. Box ED
Tofol, Kosrae FM 96944
Phone: (691) 370-3189/3208

MARSHALL ISLANDS
Mr. Bedinin Joseph
Ms. Juanita Rilometo
Ministry of Education
Box 3
Majuro, MH 96960
Phone: (692) 625-5261/2

YAP
Ms. Ginny Fenenigog
P.O. Box 220
Colonia, Yap FM 96943
Phone: (691) 350-2146

PALAU
Mr. Tangy Anastacio
Ms. Bernie Keldermans
Mr. April Olkeriil
Ministry of Education
P.O. Box 189
Korror, PW 96940
Phone: (680) 488-2547/2952

POHNPEI
Mr. Pernis Diopulos
Mr. Martin Weirlangt
Ms. Selihter Joseph
Department of Education
P.O. Box 250
Kolonia, Pohnpei 96941
Phone: (691)320-2146/2102

Chinese Proverb of Learning

Tell me, I forget!

Show me, I remember!

Involve me, I understand!

I hear, and I forget!

I see, and I remember!

I do, and I understand!

PACIFIC REGION EDUCATIONAL LABORATORY
828 Fort Street Mall ◆ Suite 500
Honolulu, Hawaii 96813-4321
(808) 533-6000 ◆ FAX: (808) 533-7599
e-mail: askprel@prel.hawaii.edu